Thomas A. Edison Papers

A SELECTIVE MICROFILM EDITION

PART II
(1879–1886)

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46

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THOMAS A. EDISON PAPERS

A SELECTIVE MICROFILM EDITION
PART II
(1879-1886)

REEL 46

LITIGATION SERIES (LIT-4)

Patent Interferences

Court Records
Seyfert v. _Edison_

LITIGATION SERIES, 1879-1886

The Litigation Series contains the printed records of civil court litigation, along with the records of Patent Office interferences, which are similar in many respects to litigation. These records consist of pleadings, testimony, exhibits, attorneys' briefs and arguments, and decisions and opinions of the court or hearing examiner.

During the 1880s Edison was involved in several patent interferences relating to his work in electric lighting. Of particular importance is the interference with William E. Sawyer and Albon Man over Edison's carbon lamp patent (U.S. Patent No. 223,898), which later moved to the federal courts as a patent infringement suit brought by the Edison Electric Light Company (see below). All of the remaining interferences also concern electric light patents, except for one interference with Henry C. Nicholson regarding duplex telegraph patents. The patent interferences provide valuable information about Edison's work in electric lighting and power, electric traction, and duplex telegraphy, as well as documentation about the operation of the Menlo Park Laboratory. All of the interferences have been filmed except for a handwritten copy of the testimony on behalf of Edward Weston in an interference over the electrical transmission of power. Another set of patent interferences from the 1880s, relating to conflicting claims over telephone inventions, can be found in Thomas A. Edison Papers Microfilm Edition, Part I, reel 11.

The printed court records for the period 1879-1886 pertain to four separate cases. The earliest case involves a suit brought against Edison in 1880 by Lucy Seyfert. Mrs. Seyfert was the widow of an investor in the Automatic Telegraph Company who had loaned Edison money as part of a business arrangement regarding Edison's automatic telegraph patents. She brought suit against Edison in order to collect on a promissory note. The testimony in this case provides insight into Edison's relations with his financial backers and his financial difficulties during the mid-1870s.

The patent infringement suit against Sawyer and Man -- Edison Electric Light Company v. United States Electric Lighting Company -- was the most important piece of electric light litigation brought by the Edison interests and the only electric light suit initiated prior to 1887. Included as exhibits in this case are parts of the printed records from the earlier patent interference (Sawyer and Man v. Edison) and from two contemporary electric light cases (the McKeesport Case and the Trenton Feeder Case). Together, these records constitute a particularly valuable source for documenting Edison's work in electric lighting.

Two related patent infringement suits were brought by the Edison and Swan United Electric Light Company, Ltd. against the partnership of Woodhouse & Rawson. These suits were argued strictly on technical points concerning the validity of the various patents. Another British infringement case concerns the telephone patents of Edison and Alexander Graham Bell. The arguments in this case were also narrowly confined to technical issues regarding the validity of the patents. Beyond documenting Edison's patent claims, these British cases do not provide insight into Edison or his work, and they have not been filmed.

The following documents comprise the Litigation Series:

INTERFERENCES

1. Bound Dynamo Cases

   a. Edison v. Siemens v. Field (1881)
   b. Keith v. Edison v. Brush (1881)

2. Miscellaneous Bound Interferences

   a. Mather v. Edison v. Scribner (1883 - dynamo or magneto electric machines)
   b. Edison v. Lane v. Gray v. Rose v. Gilliland (1882 - magneto electric machines)
   c. Edison v. Nicholson (1880 - duplex telegraphy)
   d. Sawyer and Man v. Edison (1881 - lamp filament [U.S. Patent No. 223,898])
   e. Edison Electric Light Company v. United States Electric Lighting Company [bill of complaint] (1885 - lamp filament [U.S. Patent No. 223,898])

3. Unbound Interferences

   a. Edison v. Gray & als. (1883 - magneto electric machines)
   b. Edison v. Maxim v. Swan (1883 - electric lamp)
   c. Edison v. Sprague (1885 - electric meters)
   d. Sprague v. Edison (1885 - electric meters, case B)
   e. Weston v. Edison (1882 - dynamos or magneto electric machines)
   f. Weston v. Edison (1883 - electrical transmission of power) NOT FILMED

PRINTED COURT RECORDS

1. Seyfert v. Edison (1880 - suit over Edison promissory note)
2. Edison Electric Light Company v. United States Electric Lighting Company (1885-1892 - infringement, lamp filament [U.S. Patent No. 223,898])
3. Edison and Swan v. Woodhouse and Rawson (1886 - carbon lamp patents) NOT FILMED
4. United Telephone Company, Ltd. v. Harrison, Cox-Walker and Company (1882 - telephone patent infringement case) NOT FILMED

Bound Dynamo Cases, 1881

This volume contains the printed record of testimony on behalf of Edison from two patent interferences in 1881. The spine is stamped "Edison Testimony Edison vs. Siemens vs. Field Electric Railroad" and "Edison Testimony Keith vs. Edison vs. Brush On Dynamo Electric Machines 1881 Chas. Batchelor."

The following cases comprise this volume:

(1) Edison v. Siemens v. Field. This 218-page pamphlet contains testimony by Edison, Charles L. Clarke, Francis R. Upton, and other associates concerning Edison's efforts to design and construct an electric railroad at Menlo Park in 1880.

(2) Keith v. Edison v. Brush This 119-page pamphlet contains testimony by Edison, John Kruesi, Francis R. Upton, and other associates concerning Edison's work on the dynamo between 1878 and 1881. Edison's testimony also contains significant references to his activities between 1869 and 1873.

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2

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IN THE U. S. PATENT OFFICE.

EDISON
vs.
SIEMENS
vs.
FIELD.

System of Electro-Magnetic Railroading. 2

To F. L. Pope, Att'y for S. D. Field:

Please take notice that on Wednesday, November 16th, 1881, at ten o'clock A. M., at No. 65 Fifth avenue, New York City, I will proceed to take the 3
testimony of Thos. A. Edison, Chas. L. Clarke, Francis R. Upton, Julius Hornig and others, in behalf of said Edison, and continue the examination from day to day until completed.

You are invited to be present and cross-examine.

Dyer & Wilber,
For T. A. Edison.

Good service this 14 day of November, 1881.

Frank L. Pope,
Att'y for Field. 4

9480

5

IN THE U. S. PATENT OFFICE.

EDISON *vs.* SIEMENS *vs.* FIELD.	System of Electro-Magnetic Railroading.

6

To C. S. Whitman, Att'y for E. W. Siemens:

Please take notice that on Wednesday, November 16th, 1881, at ten o'clock A. M., at No 65 Fifth avenue, New York City, we will proceed to take the testimony of Thos. A. Edison, Chas. L. Clarke,
7 Francis R. Upton, Julius Hornig and others, in behalf of said Edison, and continue the examination from day to day until completed.

You are invited to be present and cross-examine.

Dyer & Wilber,
For T. A. Edison.

Good service this 15 day of November, 1881.

C. S. Whitman,
Att'y for Siemens.

8

IN THE UNITED STATES PATENT OFFICE. 9

EDISON *vs.* SIEMENS *vs.* FIELD.	System of Electro-Magnetic Railroading.

10

Pursuant to the foregoing notices the parties attended before me at No. 65 Fifth avenue, New York City, this 16th day of November, 1881, at 10 o'clock A. M., for the purpose set forth in said notices.

Present—Geo. W. Dyer, Esq, Counsel for Edison, C. S. Whitman, Esq., Counsel for Siemens, Wm. D. Baldwin, and F. W. Whitridge Esqs., Counsel for Field. 11

Wm. H. Meadowcroft,
Notary Public,
New York County.

Julius L. Hornig, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows, in answer to questions proposed to him by George W. Dyer, counsel for Edison :

Q. 1. Please state your name, age, residence and occupation? 12

A. Julius L. Hornig; Jersey City, N. J.; mechanical engineer; age, 52.

Q. 2. Did you enter into the employ of Mr. Thos. A. Edison, and if so, when and where, and in what capacity?

A. I entered Jan 4, 1880, in the capacity of draughtsman, at Menlo Park, to design central stations.

Q. 3. At what time, if ever, did Mr. Edison set you at work upon his electric railway?

13 A. The latter part of March, 1880.

Q. 4. In what capacity?

A. To lay a track of half a mile length, and design the locomotive and cars.

Q. 5. At what time were the rails procured for the railroad track?

A. The first part of April, 1880.

Q. 6. When was work commenced at laying the railroad track?

A. From records at this office, April 11, 1880.

14 Q. 7. When was the railroad completed, so as to be fit for operation?

A. The rails and track were all ready and connected by May 11, 1880.

Q. 8. When did electric trains begin to run over that railroad?

A. May 13, 1880.

Q. 9. Describe the train, including the locomotive, which began running over the railroad at the date last mentioned?

15 A. One passenger car was coupled to the locomotive. The locomotive is composed of a dynamo machine supported by iron frame and carried on two axles with isolated wheels on light rails. The front or driving wheels were provided with a friction wheel fastened to their axle, and received motion from the armature shaft, the latter being provided also with a friction wheel. An intermediate friction wheel, operated by hand of the engineer, transmitted power from the armature to the driving wheels.
16 The rear wheels and axle, with springs under the frame, were merely for carrying. The rims of the driving wheels being isolated from the motor, received the electric current by contact with the rails. Brushes took the current from these rims through the motor. A brake lever to break the current or change contacts was provided, so that the operator could produce forward or backward motion of the motor, or break the passage of current through the motor; that is, stop its action. A governor was supplied, in the shape of customary ball governors,

to operate a lever which operated four contact 17
levers, to break the current in four points at a given speed of governor. A brake lever was also provided to brake on the friction wheel of the driving shaft for stopping or retarding the speed of the motor. A customary buffer and coupling link at the rear of the locomotive was provided to connect the passenger car. The passenger car was a platform car with springs resting on two axles with isolated car-wheels. Seats were on the platform for six passengers. Couplings and brakes were provided in the 18
customary way.

Q. 10. Please describe more fully and more clearly the method and apparatus by which the current received from the rails into the locomotive caused the same to move?

A. From the insulated tire of the driving wheel through a metallic spider provided with a hub of small diameter, the brush would take up the current from the hub. The brush fastened to the platform of the locomotive was insulated and connected by 19
wire to the hand-brake or reversing contact apparatus. From this apparatus wires would connect to the field and armature of the dynamo machine and produce motion, one rail carrying to one line of wires, the other rail conducting to make the circuit. The armature being revolved by the electric current action of the dynamo machine, being provided with a friction wheel, transmitted motion to the driving wheel by means of friction wheels.

Q. 11. What means, if any, were adopted to make 20
the rails conductors of electricity throughout the length of the track?

A. The rails were laid free from the ground on wooden ties, spiked to those ties. The rails were connected for continuation by means of fish plates and copper rods, the rods being clamped against the rails by the fish plates.

Q. 12. Was care exercised with regard to the size of the ties and the length of the spikes? If so, for what purpose?

21 A. The ties were selected to be of sufficient thickness not to let the point of the spike penetrate through them into the ground, for the purpose of keeping the rail insulated.

Q. 13. How was a current of electricity produced in these rails?

A. Dynamo machines operated by a steam engine at the station furnished the current, which was conducted by means of wires or cables underground across a street to the nearest end of the rails of the
22 railroad track.

Q. 14. Where was the steam engine and the dynamo machine driven by it placed?

A. They were at the machine shop and its extension at Menlo Park.

Q. 15. How long was that railroad train run electrically at Menlo Park before any change was made in the locomotive?

A. One single outward trip when one friction wheel broke.

23 Q. 16. Was any change made then; if so, what was the change?

A. The change was made at once, removing the friction wheels, adopting pulleys with belts, adding at the rear, brackets to carry a counter shaft with pulleys for suitable transmission.

Q. 17. Explain how that was done?

A. The pulley on the armature shaft by means of a belt to the pulley on the counter shaft, would transmit motion to the counter shaft, from a second
24 pulley on this countershaft to a pulley on the driving axle by means of a belt, motion was given to the locomotive.

Q. 18. How much time was occupied in making this change?

A. About 24 hours.

Q. 19. When was the running of the trains electrically resumed after this change was made?

A. At once after connecting the belts.

Q. 20. How constant was the running of these trains electrically, afterwards?

A. Almost daily for the following season. 25

Q. 21. Are that locomotive and that car still at Menlo Park?

A. They are.

Q. 22. Fit for present use?

A. Apparently in complete order.

CROSS-EXAMINATION BY F. W. WHITRIDGE, OF COUNSEL FOR FIELD:

x-Q. 23. Please explain more fully what you mean by being employed in the capacity of draughtsman, 26
to design central stations?

A. Mr. Edison was exhibiting then at Menlo Park his incandescent light; he had some dynamo machines in operation, and contemplated to erect central stations for electric lighting purposes; I was expected to make building plans, arranging steam machinery to drive his dynamo machines in central station plants.

x-Q. 24. Was that what you were engaged for by him? 27

A. That was my first understanding of occupation.

x-Q. 25. What kind of dynamo machines had he there at that time?

A. Single machines.

x-Q. 26. How many of them were there?

A. There were three or four in operation; others under construction.

x-Q. 27. Whose machines were those which were in operation? 28

A. They were Edison's machines, made by him.

x-Q. 28. For what purpose were they in operation at that time?

A. These machines referred to were producing current for light.

x-Q. 29. Were those which were being constructed of the same sort as those which were in operation?

A. They were of the same sort.

x-Q. 30. How long did you continue to be employed in designing these central stations?

29 A. With intermissions, up to the present time.

x-Q. 31. What portion of the time was occupied by those intermissions?

A. Probably one-half of the time.

x-Q. 32. What were you doing during these intermissions?

A. Constructing apparatus and making plants for various improvements in Mr. Edison's business.

x-Q. 33. Improvements of your own?

A. I worked as mechanical engineer, and laid no
30 claims to whatever novelties might have been produced by me.

x Q. 34. Some of the improvements, therefore, of which you speak were made by you, then?

A. As far as improvements are made in construction or designs by mechanical engineers.

x-Q. 35. I understand you, therefore, that during the most of this period of which you speak you were employed upon matters connected with the electric light?

31 A. I stated half the time.

x-Q. 36. How much of the other half of the time which you have testified was divided among Mr. Edison's inventions did you devote to the electrical railway?

A. About half of it, perhaps.

x-Q. 37. It would, therefore, be fair to say, if I understand you correctly, that comparatively only a small portion of this time was devoted to the electrical railway?

32 A. About one-quarter of my time.

x-Q. 38. When did you first begin to work upon it?

A. At the end of March, 1880.

x-Q. 39. Who set you at that work?

A. Mr. Edison.

x-Q. 40. What was it that he first told you to do?

A. To order rails for half a mile of experimental track.

x-Q. 41. Did he tell you what kind of rails to order, or simply tell you to lay a track?

A. He ordered me to lay the track. 33

x-Q. 42. Did he tell you what kind of track he wanted laid?

A. I understood the experimental railroad to be similar to portable tracks in the market.

x-Q. 43. Do I understand you to mean by that that Mr. Edison gave you no specific instruction about the rails and track?

A. No specific instruction in the size of rail or gauge of track, which is depending from the construction of locomotive, adopting one of his dynamo 34
machines on hand.

Counsel for Field desires memorandum made that the witness has stated that the sentence, down to the words "which is," is his answer to the question, and that counsel has requested the rest of the witness's remarks to be stricken out; and he moves that the same be stricken out accordingly, as irresponsive and irrelevant. 35

x-Q. 44. Did he give you any specific instruction about the track?

A. The track to be perfectly insulated, and connected as described above.

x-Q. 45. How long was your conversation with Mr. Edison at this time—when he gave you this order?

A. Mr. Edison gave directions during the entire construction; when he gave the order for laying the track the conversation was short. 36

x-Q. 46. Having received this order from Mr. Edison, did you immediately order the rails for the track?

A. Yes; immediately.

x-Q. 47. How long was it before you got them?

A. Eight or nine days after the order was given from the office, the rails were laid at Menlo Park.

x-Q. 48. And in the manner directed by Mr. Edison at the time when he gave you the order?

A. Yes.

37 x-Q. 49. You have testified that among the specific instructions about the laying of the track, at the time the order was given, it was directed that the track was to be perfectly insulated; was the manner of effecting that insulation described at the same time?

Counsel for Edison objects to the foregoing question as an incorrect statement of what the witness has testified to.

38 A. At that time he probably did not give me the specific instructions for insulating the track.

x-Q. 50. Are you sure whether he did or not?

A. I am not sure.

x-Q. 51. Do you know when you did get those instructions?

A. Before the first plans of locomotive were commenced.

x-Q. 52. From whom did you get them?

A. From Mr. Edison.

39 x-Q. 53. Give the time of them, as nearly as you can?

A. About the end of March or beginning of April.

x-Q. 54. Was the track constructed in this respect in exact accordance with the instructions?

A. Yes; as understood by me.

x-Q. 55. Did you receive more than one set of instructions about the insulation of the track?

A. I put questions to Mr. Edison in reference to
40 insulation and got his instructions probably at a later time also.

x-Q. 55. Was the track perfectly insulated?

A. The track was tested in reference to insulation by order of Mr. Edison by the proper parties, and was proved satisfactory.

x-Q. 56. Who were the parties?

A. Mr. Upton or his assistants.

x-Q. 57. How do you know it was satisfactory?

A. From reports given and conversations with Mr. Edison.

x Q. 58. After you had received some of his instructions of which you have spoken of insulating 41
the track, what were the questions that you asked Mr. Edison to which you refer in your answer to the 54th cross-question?

A. The question was what special connection, if any, was required between the connecting rails, and he devised copper bars to form this connection.

x-Q. 59. A portion of these devices therefore were made in response to your questions, and did not form a part of the original instructions? 42

A. Details for and during construction would come before me to get special information and instruction, explaining more fully the general directions I had received.

Counsel for Field objects to the answer as irresponsive, and moves to strike it out.

x-Q. 60. Question repeated.

A. I could not state that; I got information whenever I asked for it. 43

x-Q. 61. About how often did you have to ask for additional information?

A. A few times, at the beginning of the construction.

x-Q. 62. While you were having the track constructed were you also doing any other work for Mr. Edison?

A. I do not remember of any other before the railroad was in operation, which was about May 13th, 1880. 44

x-Q. 63. After the railroad went into operation what did your work consist of?

A. I made various constructions for the locomotive to be operated by metallic belts or gear movements during June and July, 1880.

x-Q. 64. Were you occupied altogether with that work during that time?

A. Most of the time.

x-Q. 65. This was after the substitution for the friction wheels to which you have referred?

45 A. Yes.

x-Q. 66. Was this matter all of the work which you did upon the locomotive at this time?

A. I made plans for a direct acting motor for express, letter or package transportation.

x-Q. 67. Please state as nearly as you can at what time you made those drawings?

A. During the summer or fall of 1880.

x-Q. 68. Do you mean to say that these drawings were work upon this electric locomotive of which
46 we have been speaking?

A. The same class of dynamo machine, but smaller, was to produce motion direct to driving wheels for a motor to carry or haul packages.

x-Q. 69. Your work upon the electric locomotive, however, consisted in your work upon this device or devices which were substituted for the friction wheels which you have spoken of, did it not?

A. Yes.

47 x-Q. 70. And that was the only work you did upon it?

A. Yes, upon this lomocotive.

x-Q. 71. Did you do any work upon the cars?

A. Yes; I made the plans for the first and second platform cars The first for passenger, the second for freight purposes.

x-Q. 72. When did you make those?

A. At the commencement of the construction, the axles, wheels and pedestals for locomotives and
48 cars being ordered at the same time.

x-Q. 73. When were those wheels ordered?

A. During April, 1880.

x-Q. 74. Where was the locomotive made and who made it?

A. The locomotive was made at Menlo Park. Part of the frame and gearing made by the Pioneer Iron Works of Brooklyn, to our plans. The axles and wheels were furnished by the Jersey City Car Wheel Foundry, and finished for insulation by the Pioneer Iron Works.

x-Q. 75. When was this all done?

A. During April. 49

x-Q. 76. How did you come to know about it?

A. I attended personally, instructing the Pioneer Iron Works concerning the plans and have the dates from records kept at this office.

x-Q. 77. I understood you to testify that you had done no work on this locomotive except with reference to the substitution for the friction wheels. How then does it happen that you attended to these orders?

A. I have testified, I understand, that I made the 50
plans of the first locomotive which had the friction wheels.

x-Q. 78. When did you make those plans?

A. During the latter part of March and during April, 1880.

x-Q. 79. Were these plans for the direct acting motor for express packages, or for this electric locomotive?

A. The first plans made were for the locomotive.
The plans for the direct acting motor were made 51
later.

x-Q. 80. When you testified that your only work upon this locomotive was with reference to the substitution for the friction wheels, had you forgotten that you made the plans for the locomotive, or do you mean that the plans you made were for the friction wheels for which you subsequently substituted something else.

A. No; I had not forgotten it; and in so stating
I referred to the work I did after the road was in 52
operation.

x-Q. 81. Were those plans complete?

A. General and detail plans were made to enable the mechanics to construct the machine.

x-Q. 82. Did you make the whole of them?

A. I did.

x-Q. 83. How did you come to make them?

A. By order and direction of Mr. Edison.

x-Q. 84. Give a general account of your orders in

53 this matter, and of the work you did in accordance with them?

A. Mr. Edison expressed his wish and intention to build one-half mile of experimental electric railroad at Menlo Park, in the latter part of March, 1880, having desired a year previous or more to make extensive experiments. Not more than four days after this conversation I procured information in reference to procuring rails and car wheels, and the orders were given to me to order rails at once. And
54 instructions and information necessary to me to construct, as afterwards carried out, were given to me.

x-Q. 85. If you entered Mr. Edison's service January 4, 1880, how do you know about what he desired to experiment about nine months before?

A. Mr. Edison mentioned in a conversation what I stated before.

x-Q. 86. The information and instructions about the plans of the locomotive were given to you after
55 or before you had ordered the rails?

A. Before and after.

x-Q. 87. Were they oral or written?

A. Oral.

x-Q. 88. How long a time were you in getting the whole of them?

A. Mr. Edison was in and out almost daily while I was constructing, and nights conversations took place.

x-Q. 89. Do you remember when you first began
56 to make those plans?

A. I am sure it was near the end of March.

x-Q. 90. And you have no means, I understand you, of stating specifically when you got your instructions from Mr. Edison?

A. I have not.

x-Q. 91. Can you remember his language at any one of the times that he gave you these instructions, exactly?

A. I cannot now remember.

x-Q. 92. How specific were these instructions for

these plans, and are you sure that they were entirely oral, as you have testified? 57

A. Mr. Edison has made occasionally sketches in perspective, and has given me for other designs some such sketches; but I am not aware that I have one such sketch in reference to this railroad construction.

x-Q. 93. Do I understand you correctly therefore, that the information furnished you by Mr. Edison was less specific in this case, than in the case of other designs which you have above referred to? 58

A. I do not consider it less specific. Some hasty instructions were given by him occasionally by perspective sketches. I do not consider this less specific because he did not give me sketches.

x-Q. 94. How long a time were you in completing the drawings?

A. From March to the middle of May.

x-Q. 95. The engine which ran upon May 13th was exactly and in all respects represented by those drawings, was it? 59

A. Yes, sir.

x-Q. 96. When was the engine taken off after it was first used?

A. It was used one outward trip, and about 24 hours later it was operated by belts and kept in operation for the season.

x-Q. 97. Why were the belts substituted for the friction wheel?

A. Mr. Edison gave directions at once to make a belt connection and get the locomotive running 60
without delay, after the breakage of the friction wheel.

x-Q. 98. Why did the friction wheel break, do you know?

A. The friction wheel which broke was made in two halves bolted together and keyed to the driving axle. Imperfect fitting or accidental abuse of these working parts may have caused the breakage.

x-Q. 99. Do you know why the engine was not repaired in accordance with the original design?

61 A. I do not.
x-Q. 100. You heard nothing said about that?
A. Nothing.
x-Q. 101. You made the plans for the device substituted for the friction wheels, did you not?
A. I made diagram lines at once on the general plan, adopting pulleys then on hand in the machine shop of Menlo Park.
x-Q. 102. Do you remember what time of day that was?
62 A. Evening.
x-Q. 103. What time of day did the engine break down?
A. Towards evening.
x-Q. 104. How did you come to make these plans?
A. Mr. Batchelor and Mr. Kruesi were directed at once by Mr. Edison to find pulleys. My attention was called to arranging the placing of such pulleys suitably to the space in the frame of the locomotive.
63 x-Q. 105. Which of these gentlemen called your attention to that?
A. Mr. Batchelor or Mr. Kruesi.
x-Q. 106. And the improvement in the engine was made the next day in accordance with the diagrams made in accordance with these suggestions, was it?
A. Yes. They were started the same evening and completed the next day.
x-Q. 107. Has the engine in its present condition been in any respect altered since this alteration of
64 which you have been speaking.
A. The engine is identically the same way fitted up as it was in operation formerly under belt connection. The only addition is the brush arrangement for the rear wheels, which is the same as was first applied for the driving wheels only.
x-Q. 108. Was there at any time an arrangement of sprocket wheels and chains used on the engine?
A. Not that I know of.
x-Q. 109. Was there any tooth or spur gearing used on the engine?

A. Yes, sir. Worm and spur gear were placed on 65
this locomotive, according to the plans mentioned and the experiments made operating the locomotive on the track at Menlo Park.
x-Q. 110. When was that done?
A. During the fall of 1880.
x-Q. 111. Then the engine has been altered since the time it was used in May, 1880?
A. Yes; the belt arrangement was taken off and a gear arrangement, to be tested, put on the ma-
chine, and the gear arrangement taken off again, to 66
be replaced by the first belt arrangement.
x-Q. 112. This refers to the gearing apparatus between your dynamo and the driving wheels of the locomotive, does it not.
A. Yes.
x-Q. 113. What was the reason why the gearing arrangement between the dynamo and the driving wheels was thus altered?
A. The friction clutch which, for want of room,
was necessitated to be of small size, worked not to 67
entire satisfaction at the first test. The perfecting of the proper working of the clutch was commenced, but not completed to my knowledge.
x-Q. 114. What is the gearing arrangement now upon the locomotive?
A. The belt arrangement.
x-Q. 115. When was that replaced?
A. I cannot tell, having been away from Menlo Park since March, 1881, and only inspected yester-
day the locomotive at Menlo Park. 68
x-Q. 116. The tooth and spur gearing would appear, therefore, to have been used on the engine between the fall of 1880 and March, 1881, at least, would they not?
A. I have been present at the test of this gearing in the fall, but have not seen this in operation but twice or three times for testing this gearing, since commencing repairs on the clutch. I have not seen this gear in operation, and cannot state what occurred in my absence from Menlo Park.

69 x-Q. 117. Which of these gearing arrangements was in use on that engine in March, 1881, when you saw it?

A. I cannot tell.

x-Q. 118. You have no means of knowing when the belting arrangement was replaced, then, have you?

A. No.

x Q. 119. You do know that it has been replaced?

A. I do.

70 x-Q. 120. Do you know why?

A. I do not.

x-Q. 121. Do you know whether the friction clutch, of which you have spoken, was at any time broken before the belted gearing was substituted?

A. I do not think it was broken.

x-Q. 122. Do you know whether this spur gearing broke while it was on the engine?

A. I don't know of anything breaking.

x-Q. 123. You never heard in any way whether
71 this toothed spur gearing broke or not, while it was used on the engine?

A. I never did. This spur gearing is at Menlo Park, according to yesterday's inspection, sound and in good order, the same as I noticed when the clutch was taken out for adjustment.

CROSS-EXAMINATION BY CHAS. S. WHITMAN, COUNSEL FOR SIEMENS:

x-Q. 124. In whose employ were you before you
72 were employed by Mr. Edison?

A. In that of Mr. Krom, mining engineer, Liberty street, New York.

x-Q. 125. How long were you in Mr. Krom's employ?

A. Probably two months.

x-Q. 126. Was Mr. Krom simply a mining engineer, or did he combine other branches of engineering with his business?

A. To my knowledge his business was construct-

ing mining machinery and mining plants on some of 73
his patents.

x-Q. 127. I understood you to state, that you were a machanical engineer. You are also an electrical engineer, are you not?

A. I am a mechanical engineer, but not an electrical engineer, having paid no attention to that branch of engineering before being employed by Mr. Edison.

x-Q. 128. Had you had no experience whatever
in electrical constructions or electrical matters, be- 74
fore you entered Mr. Edison's employ?

A. None whatever since leaving the polytechnic school, about twenty-five years ago.

x-Q. 129. To what polytechnic school do you allude?

A. The polytechnic school of Dresden, Saxony.

x-Q. 130. Is not the course of instruction in electrical science very thorough at that institution?

A. Not at the time when I studied there; and I
attended particularly to the courses of mechanical 75
engineering.

x-Q. 131. Please state, as nearly as you can, what, if any, electrical studies you pursued at that institution?

A. The primary instruction was experiments by the professor in galvanic actions and frictional electricity.

x-Q. 132. You obtained then at that time a general knowledge of electrical currents and their action,
did you not? 76

A. Yes, in reference to galvanic batteries.

x-Q. 133. When was your attention next called to electrical matters after leaving the polytechnic school?

A. I have paid no special attention to electrical matters, only the electric light, becoming prominent lately, called my attention to study up the electric engineering.

x-Q. 134. State as nearly as you can when you first commenced to study up electrical engineering?

77 A. Only after I commenced to work for Mr. Edison at Menlo Park.

x-Q. 135. You commenced the study then of electrical engineering after you were first employed by Mr. Edison, and before you received instructions from him concerning the electric railway, did you not?

A. As far as observation at the laboratory, and work on electrical apparatus at the shops could inform me at leisure time.

78 By consent, the taking of further testimony was postponed to Thursday, November 17th, 1881, at ten o'clock A. M., at same place.

Wm. H. Meadowcroft,
Notary Public,
New York County.

Pursuant to adjournment the taking of testimony was continued on Thursday, November 17th, 1881,
79 at same place, same counsel being present.

x-Q. 136. How long have you been in this country?

A. Since 1851.

x-Q. 137. You speak and write the German language, do you not?

A. Yes, it is my native language.

x-Q. 138. When were you in Europe last?

A. In 1858.

80 x-Q. 139. When and where did you first become acquainted with Mr. Edison?

A. January 4th, 1880, at Menlo Park.

x-Q. 140. How were you employed at Menlo Park from the time January 4th, up to the time that you received instructions concerning the electric railway?

A. I was making general plans to place dynamo machines of the number and size given by Mr. Edison in a building of 225 feet front and 100 feet deep; and to arrange the steam machinery and boilers suitable for the purpose in the same building. Different proposed classes of boilers and steam engines 81
required various plans of arranging and driving the dynamo machines.

x-Q. 141. Have you any way of fixing the date on which Mr. Edison first spoke to you concerning electric railway?

A. From records in this office I find the rails were ordered April 2, 1880, and about four days previous the first mention of electric railroad by Mr. Edison was made.

x-Q. 142. Mr. Edison then first mentioned an 82
electric railway to you on the 29th day of March, 1880, did he?

A. I should think it was about the 29th.

x-Q. 143. As a mechanical engineer I suppose that you are in the habit of reading periodicals and publications having reference to your occupation, are you not?

A. I do, and have done so.

x-Q. 144. Your acquaintance with the German language, I presume, gives you the advantage of 83
being able to make yourself acquainted with the latest improvements in mechanical science taking place in German speaking countries, does it not?

A. It does.

x-Q. 145. Are you a regular subscriber for any piiodicals having reference to your profession, printed in the German language?

A. I am not.

x-Q. 146. Do you have access to any such publications or periodicals? 84

A. I have access to them, but do not make use of it.

x-Q. 147. Can you give the names of the persons who were employed with you at Menlo Park in the laying down of the rails for Mr. Edison's railway?

A. One carpenter, H. A. Campbell. That is the only name I can remember of the carpenters and laborers working on the track.

x-Q. 148. Do you know whether any of the persons who assisted you in laying the rails at Menlo

85 Park were employed in laying the rails for the Siemens Electric Railway which were laid in Berlin in the spring and summer of 1877?

A. It seems impossible from the class of men employed.

x-Q. 149. In your answer to question 9, you say the locomotive is composed of a dymano machine supported by an iron frame and carried on two axles with isolated wheels, on light rails. What do you mean by a dymano machine?

86 A. I mean the dynamo machine as operated and in service at Menlo Park by Mr. Edison.

x-Q. 150. You say in answer to the same interrogatory, "the front or driving wheels were provided with a friction wheel fastened to their axle, and received motion from the armature shaft, the latter being provided also with a friction wheel." Please describe the construction of the armature shaft, to which you have alluded?

A. The armature shaft resting in bearings which
87 were fastened to the frame of the engine admitted the placing of the friction wheel in place of the pulley which was used on such dynamo machine when formerly employed for producing current for the lights.

x-Q. 151. How was the armature wound?

A. I am not informed how it was wound.

x-Q. 152. Could you not see for yourself how it was wound?

A. It had the same appearance as the armatures
88 of the Edison machines.

x-Q. 153. What appearance had those armatures?

A. The armature proper appeared to be a cylinder covered with insulated wires which connected one side of the cylinder with a smaller cylinder composed of insulated copper bars lying lengthwise.

x-Q. 153½. Did the cylinder appear to be entirely covered with insulated wire?

A. I think the insulated wires lay in contact with each other on the periphery of the cylinder.

x-Q. 154. Can you describe the construction of

the field magnets of the dynamo electric machine 89
of which you have testified?

A. The magnet had two cores which were wound with insulated wire. These cores were of wrought iron, their ends faced, for connecting them with a faced iron cross-bar and also with two cast iron field pieces. These field pieces were bored out and admitted the armature to revolve therein.

x-Q. 155. Do you mean that the field pieces were bored out in such a way as to leave a cylindrical
space within which the cylindrical armature wound 90
with insulated wire, revolved?

A. Yes.

x-Q. 156. Were the portions of the magnets inclosing this cylindrical space and field of force, curvilinear or straight?

A. Approximalety corresponding with the cylinder.

x-Q. 157. You mean, do you, that the cylinder revolved between curvilinear bars?

A. I could not call the shape of these castings
bar shaped. They represented rather, cubes. 91

x-Q. 158. Were the cubes concerning which you have testified, curvilinear or straight?

A. They were curvilinear, partly surrounding the cylinder.

x-Q. 159. You say in answer to question 10, "the brush fastened to the platform of the locomotive was insulated and connected by wire to the hand brake or reversing contact apparatus, wires would connect with the field and armature of the dynamo
machine, and produce motion." Please explain how 92
the current flowed from the rail to the field and armatures of which you have testified?

A. The current from the rail would pass through the tire of the driving wheel by its metallic spider with a small hub in contact with a brush, by wires leading from this brush to the reversing apparatus, and from the reversing apparatus by wires to the magnet and to the brushes in contact with the commutator of the armature.

93 x-Q. 160. Please describe the reversing apparatus of which you speak?

A. A hand lever provided with contact points and free between contact points of two bell cranks could be moved to one or the other side making contact with one or the other bell crank and by their wire connections to change the operation.

x-Q. 161. What became of the drawings of the locomotive which you made for Mr. Edison?

A. They probably are in my possession in this
94 office.

x-Q. 162. Have you any way of fixing the date when the first drawing was made?

A. The first drawings are not dated, but later during the progress dates appear on the drawings.

x-Q. 163. In preparing these drawings were you assisted by any person or persons who saw the electric railway of Siemens in operation in Berlin in the spring of 1879?

A. I was not assisted in making drawings by any
95 one, and knew of no one connected with Siemens.

x-Q. 164. Did you meet any one when at Menlo Park who had seen the electric railway of Siemens?

A. I have not, to my knowledge.

x-Q. 165. When did you first hear of the Siemens' electric railway!

A. I must have seen an engraving or read of an exhibition by Mr. Siemens of an electric railroad before I went to Menlo Park, but took no notice of
96 any details then.

x-Q. 266. Was it in the spring of 1879 when the Siemens railway was on public exhibition at the Berlin exposition that you saw the engraving or read of an exhibit?

A. It must have been after and in reference to that exhibition.

x-Q. 167. Are you in the habit of meeting many Germans who come over from the old country?

A. No.

x-Q. 168. Do you remember to have met any German or other foreigner or citizen of the United 97
States who mentioned the fact of having seen Siemens' electrical railway in operation at Berlin, Dusseldorf or Brussels?

A. I do not remember.

x-Q. 169. In what publication was the engraving of the railway which you say you have seen?

A. I do not remember. The first notice I remember of having taken of Siemens' railroad was after Edison's railroad was in operation.

Counsel for Siemens objects to the answer 98
as irresponsive, except the words: "I don't remember."

x-Q. 170. How was the commutator of the dynamo electric machine, concerning which you have testified as being used on the locomotive, connected with the armature wires and wires wound around the cores of the field magnets?

A. The connection between the commutator bars and the wires around the armature was made by 99
soldering the bar to a bundle of wire. Other wire connections between magnets and apparatus were directed, and I have no knowledge to describe them.

x-Q. 171. Was the electric current induced in the coils of the armature passed through the coils of the field magnets in the dynamo machine of which you have testified?

A. I do not remember the connections.

x-Q. 172. How many dynamo machines did you
see at Menlo Park? 100

A. About seventeen.

x-Q. 173. Were they all similar in construction?

A. Some were of different size. Some small ones had their armature axle in a different position to the magnet.

x-Q. 174. You speak of these dynamo machines as being Edison's machines. Do you mean that he invented them, or that he owned them?

A. It is understood that Mr. Edison constructed

101 these machines with devices of his own, and of proportions to make it a specific machine.

x-Q. 175. How did you receive your pay from Mr. Edison?

A. Regularly, in money.

x-Q. 176. Are you, or have you been, a holder of any stock in any company based upon Mr. Edison's patents?

A. I have no stock of any kind of Mr. Edison's stocks. I have bought once and held some stock in
102 one of Edison's mining enterprises.

x-Q. 177. About for how long a time was the locomotive, concerning which you have testified, in continuous operation?

A. The longest time probably thirty minutes of continual running on the track.

x-Q. 178. Were they obliged to stop at the end of thirty minutes because the armature became heated?

A. Not that I am aware of, and I have heard of no complaint of heating of the armature while the
103 railroad was in operation.

x-Q. 179. Was a third rail used in any of Mr. Edison's experiments at Menlo Park?

A. Not during my presence and experiments.

Re-examination by George W. Dyer, Counsel for Edison:

Re-d. Q. 180. Have you ever professed, or do you now profess, to be anything but a mechanical engineer?

104 A. I am not anything more than a mechanical engineer.

Re-d. Q. 181. When you testified, in the cross-examination, about a friction clutch, in some connection with a cog gear, upon the locomotive of Mr. Edison, what was the office of that friction clutch, as you term it?

A. To make connections between gearing, either to a slower speed of locomotive or to a faster speed of locomotive.

Re-d. Q. 182. It was then a shifting gear-clutch, 105
wasn't it?

A. It was.

Re-d. Q 183. Do you know the object or purpose of Mr. Edison in experimenting with this cog-gear instead of the pulley belt-gear, in his locomotive?

Counsel for Field objects to the question as incompetent.

A. Mr. Edison's desire to produce a very slow motion of the locomotive called out the propriety of 106
employing some gearing device.

Re-d. Q. 184. Why did he want a slow motion?

Same objection.

A. He spoke of hauling heavy loads on steep inclines, and directed me to extend the track into a gulch.

Re-d. Q. 185. The purpose, then, was to get greater strength of traction, with less speed, was it?

Same objection, and also as leading. 107

A. With slower speed heavy loads can be hauled with the same expenditure of power.

Re-d. Q. 186. What was the relative size of the cog gears, engaging with each other, when low speed was desired, and when high speed was desired?

A. In one instance the smaller gear drives a larger, and in the other a larger gear drives a smaller gear.

Re-d. Q. 187. Do you know what rate of speed 108
that engine developed at the slow rate of gearing, and what at the high rate of gearing?

A. At the slow rate, by this gearing, the speed was designed to be, and in service was, apparently, the same—that is, a speed of four miles per hour. The fast speed by this gear was about twelve miles per hour, as far as I can remember.

Re-d. Q. 188. Please answer with regard to the pulley-belt arrangement?

109 A. The speed of the belt arrangement was an av-
erage speed of twenty miles per hour.

Re-d. Q. 189. What do you mean by your answer
to cross-question 177 where you say the longest time
the locomotive was in continuous operation was
probably thirty minutes?

A. The length of the track permitted the belt lo-
comotive to make the outward trip in about thirty
minutes. For reversing for the return trip a stop-
page of some duration limits this mentioned dura-
110 tion.

Red. Q. 190. Do you mean to be understood that
the engine was half an hour running half a mile?

A. I understood the longest duration on this trip
and know that distance of half a mile track has
been made at a rate of over twenty—some observers
claiming thirty—miles an hour.

RE-CROSS-EXAMINATION BY MR. WHITRIDGE:

Re-x-Q. 191. After the engine had been used to
111 make a trip, how long was it before it was again
set in motion or operation.

A. Usually at once. The trips were repeated.

Re. x-Q. 192. How many trips were made in im-
mediate succession to each other in this way, and
how long a time was occupied in making the whole
of the trips together?

A. Three and four trips at a time to my observa-
tion; and the whole operation lasted for some hours
when I had occasion to observe the track.

112

JULIUS L. HORNIG.

JOHN KRUESI, a witness produced in behalf of Mr. 113
Edison, being duly sworn, testifies as follows in an-
swer to questions proposed to him by George W.
Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and
occupation?

A. John Kruesi, age 38; residence, 49 Putnam
avenue, Brooklyn; occupation, Treasurer of the
Electric Tube Company.

Q. 2. Were you in the employ of Mr. T. A. Edison
at Menlo Park during the years 1878, 1879 and 1880; 114
and if so, in what capacity?

A. I was engaged during this time by Mr. Edison
as foreman of the mechanical department.

Q. 3. Do you know of Mr. Edison's making a
trip out West in 1878; if so, during what part of
the year was it?

A. I think he started the first part of July and
returned in August.

Q. 4. Do you know whether or not during that
trip of Mr. Edison's out West his attention was 115
called to the subject of electrical railways, and if
so, what called his attention to that subject?

> Question objected to by counsel for Field
> and Siemens as attempting to introduce hear-
> say evidence.

A. As Mr. Edison related afterwards when we
spoke of electric railroading, he mentioned that
during his trip out West he conceived that an elec-
tric railroad would pay in wheat-growing States, as 116
Iowa. He was informed that in Iowa they cart
wheat 200 miles on wagons. The country was per-
fectly flat, and if such a railroad was slightly ele-
vated it would require very little attention.

Q. 5. Did he at any time after that, and if so,
when, begin to make sketches and plans and esti-
mates for an electric railway?

A. He made sketches, estimates and plans the
last part of April and first part of May, 1879.

Q. 6. Have you sketches made by him or under

117 his direction about that time connected with electric railways; if so, produce them?

All sketches are objected to by counsel for Siemens and Field not shown to be made by this witness.

A. I have, and produce the same.
Q. 7. Upon this sketch which I now hand you is written "May 18th, 1879, E. tramway. J. K." In whose handwriting is that?
118 A. It is my handwriting.
Q. 8. What does that "J. K." stand for?
A. For my name, John Kruesi.
Q. 9. When was that sketch made?
A. On or previous to the date it bears—the 18th of May, 1879.
Q. 10. Do you know by whom it was made?
A. By Mr. Edison.
Q. 11. Do you recollect whether you saw him make it or not?
119 A. Yes, sir; I saw him making it.
Q. 12. In whose handwriting is the writing upon it, other than that to which I have before called your attention?
A. It is in Mr. Edison's handwriting.

Sketch is put in testimony and marked "Edison's Exhibit No. 1."

Q. 13. I call your attention to another sketch and ask you to read what is written upon it?
A. "May 18th, '79, Elec. tramway, 18 in of grd.,
120 J. K."
Q. 14. In whose handwriting is that?
A. In my own handwriting.
Q. 15. What is the "J. K." for?
A. It stands for John Kruesi.
Q. 16. Do you know when that sketch was made?
A. On or previous to May 18, 1879.
Q. 17. Do you know who made the sketch?
A. Mr. Edison.
Q. 18. Did you see it made.

A. I think he made it for me while I was looking at it. 121

Sketch is put in evidence and marked "Edison's Exhibit No. 2."

Q. 19. Please examine the sketch I now show you and state what is written at the top of the sketch, and in whose handwriting, if you know?
A. "Elc. tramway, May 18, '79, J. K." It is in my own handwriting.
Q. 20. When was that sketch made, and by whom, if you know? 122
A. It was made by Mr. Edison, or rather I recognize it as Mr. Edison's sketching, and think it was made at the date written upon it, or previous to that date.

Sketch referred to put in evidence and marked "Edison's Exhibit No. 3."
Exhibit objected to by counsel for Siemens and Field, as not being properly identified as having been made by Mr. Edison or under his direction. 123

Q. 21. Do you know that this sketch you have testified about, being Edison's Exhibit No. 3, was made by Mr. Edison himself or under his direction?
A. Yes, sir.
Q. 22. Please examine the sketch I now show you and read what is written upon the upper part of the same?
A. "May 18th, '79, 10 miles pr hour. elc. tramway." 124
Q. 23. In whose handwriting is this?
A. It is my handwriting.
Q. 24. When was this sketch made?
A. On or previous to May 18, 1879?
Q. 25. Who made the sketch, if you know?
A. I recognize it as Mr. Edison's sketching and writing on the sketch.
Q. 26. What words on the sketch are in Mr. Edison's handwriting?

125 A. "Same here."

Sketch referred to put in evidence and marked "Edison's Exhibit No. 4."

Exhibit objected to by counsel for Field and Siemens as not identified as having any connection with Mr. Edison, or as being made by him, or as relating to the subject matter in controversy.

Q. 27. Please examine the sketch I now show
126 you, and read what is written on the upper part of the same.

A. "May 18th, '79, E. tramway, J. K."

Q. 28. In whose handwriting is this.

A. In my own handwriting.

Q. 29. When was that sketch made, and by whom, if you know?

A. It was made on or before May 18, 1879, by Mr. Edison.

Sketch put in evidence and marked "Edi-
127 son's Exhibit No. 5."

Same objection as above.

Q. 30. Please examine the sketch I now show you; state what is written upon the upper part of the same?

A. "El. tramway, May 21st, 1879, J. K."

Q. 31. In whose handwriting is this?

A. In my handwriting.

Q. 32. When was the sketch made and by whom,
128 if you know?

A. On or before May 21st, 1879, by Mr. Edison.

Sketch put in evidence, marked "Edison's Exhibit No. 6."

Same objection.

Q. 33. Please examine the sketch I now show you, and state what is written on the upper part of the same?

A. "E. T. W., J. K."

Q. 34. I whose handwriting?

A. In my handwriting.

Q. 35. What is the "E. T. W." intended to stand for? 129

A. It was intended for "Electric Tramway."

Q. 36. When was this sketch made, and by whom, so far as you know?

A. It was made as far as I knew by Mr. Edison the same day as the sketch next previous, Exhibit No. 6.

Q. 37. Is there any other writing on this sketch than that you have stated, and if so, whose handwriting?

A. There is more which I recognize as Mr. Edi- 130
son's.

Sketch put in evidence and marked "Edison's Exhibit No. 7."

Objected to on same ground as before.

Q. 38. Please re-examine sketch "Edison's Exhibit No. 1," and explain what is illustrated and described thereon, putting letters of reference to the parts as you describe them?

Question objected by counsel for Siemens 131
and Field, as incompetent, as an attempt to explain Mr. Edison's sketches, and to define his invention or conception by secondary evidence.

Q. 39. Before you answer that question I will ask another, namely, did Mr. Edison explain these sketches to you, at or about the time written upon them?

A. Yes, sir; he did. 132

Q. 40. Will you now have the kindness to answer Question 38?

Objection repeated.

A. As far as I remember now, A is a dynamo machine run by a belt from a shaft with fast and loose pulley; *c* represents the belt shifter. B is a dynamo machine; D a circuit breaker.

Q. 41. Does the sketch show any connection between the machines A and B?

133 A. There is a sketch here which I think is intended for that.

Q. 42. What do you understand by the part of the sketch upon which is written "shaft"?

A. I understand that it is intended to show the belt coming from the shaft which gives the armature of the dynamo machine, B, motion.

Q. 43. What do you undersand the lower portion of the sketch to be, marked D, with its connections?

134 A. I understand it to be a device for reducing the spark in breaking the current.

Q. 44. Do you remember for what purpose this portion marked D was to be applied?

A. No.

Counsel for Field and Siemens formally request counsel for Edison to state the purpcse for which the explanations by the witness of Exhibit No. 1 are introduced into the
135 testimony.

Counsel for Edison answers that it is by way of explanation and for other purposes.

Counsel for Field gives notice of motion to strike out the same, in so far as it is to be used as evidence of the invention of Mr. Edison of the subject matter in interference, or of Mr. Edison's intention as to what the drawing was intended to represent, on the ground that it is secondary, incompetent, and hearsay
136 testimony.

Q. 45. Please re-examine "Edison's Exhibit No. 2," and state what the same illustrates, designating the particular parts by letters, if necessary?

A. Figure A represents an electric motor. Figure B represents a car attached to the motor. C represents a cross-section of trestle-work; D the plan of same; E the governor.

Q. 49. Do you find anything to represent wheels in Figures A and B?

A. Yes, sir.

Q. 47. Do you find anything to represent rails in that sketch, upon which the wheels run? 137

A. Yes, sir.

Q. 48. What does the figure in the lower part of the sketch rrepesent?

A. As far as I can see, an iron rail.

Q. 49. A railroad rail?

A. No; a strap rail for the wheels to run on.

Counsel for Field and Siemens make the same objection, and give notice of the same motion with reference to the testimony about 138
Exhibit 2, as to that regarding No. 1.

Q. 50. Please examine again Edison's Exhibit No. 3, and explain what is illustrated there?

A. I find illustrated a trestle-work, similar to that shown in the Exhibit marked No. 6, which is put together in sections. The figure below represents a trestle of a different construction.

Q. 51. What is the trestle-work for?

A. As far as I remember, it was intended for elec-
tric railway, elevated from the ground a certain 139
height.

Q. 52. Do you find railroad tracks shown on the same?

A. There are strap rails shown.

Q. 53. Secured on longitudinal timbers?

A. Yes.

Same objection to testimony regarding Exhibit No. 3, as to No. 2.

Q. 54. Please examine Edison's Exhibit No. 4, 140
and explain what is illustrated in that sketch?

A. I think it represents a current reverser to run the trains on the road forward or backward from the station.

Q. 55. What do you understand the square portions inserted between lines in multiple arc fashion represent?

A. I understand they represent dynamo machines.

Q. 56. What do you understand the heavier par-

141 allel lines with which they are connected to represent?

A. I understand that these are the two poles connected to the railroad rails.

Same objection to testimony regarding Exhibit No. 4 as to No. 3.

Q. 57. Please examine again the sketch Exhibit No. 5 and explain what is illustrated in the same?

A. The top figure represents one of Mr. Edison's
142 dynamo machines; the lower figure one of his dynamo machines provided with four railroad wheels standing on a railway track.

Q. 58. Please explain, if you can, the connections which are shown in the upper figure?

A. I see only the brushes represented, and the commutator, and armature; also one of the bearings of the pulley, and the field magnet.

Q. 59. Do you find anything else than you have described on the lower figure?

143 A. I see some parts which represent the framework and bearings of the axles.

Same objection to the testimony about Exhibit 5 as to that regarding Exhibit 4.

Q. 60. Please examine again Edison's Exhibit No. 6; state what you find illustrated there?

A. I find illustrated a station-house with a windmill, in which dynamo machines are placed, to which motion may be given by the wind-mill.
144 Wires run from the machines out to the railroad tracks. On the side track is a locomotive with two loaded cars leaving the station. The tracks are on trestle work. The lower sketch in the same exhibit represents a section of a trestle work supporting a railroad track. The other figures on the sketch, I think, are connected with telephones.

Q. 61. Do you find any estimate upon this sketch?

A. There are some figures, "400 per mile."

Q. 62. State whether or not this sketch agrees with what you know was then Mr. Edison's plan

with regard to an electric railway for transporting 145
grain in the west?

A. Yes, sir, it was.

Same objection to explanation of Exhibit 6 as to that of 5.

Q. 63. Please examine again Edison's Exhibit No. 7. State what you understand to be illustrated there?

A. I find illustrated two stations alongside the railroad track provided with telephones in separate circuits from the railway. 146

Q. 64. For what purpose?

A. For the purpose of enabling the attendants of the stations to communicate with each other, to run trains, or to govern trains from the stations without having anybody on the trains.

Same objection to explanation of Exhibit 7 as to that of the previous exhibits.

Q. 65. With regard to these exhibits, Nos. 1 to 7 inclusive, I understand the explanations you have
just been making are based upon explanations made 147
to you by Mr. Edison at or about the date of the respective sketches. Am I correct in this?

Objected to by counsel for Siemens & Field as an incompetent question, being leading and suggestive.

A. Yes, sir.

Q. 66. Did you, at or about the date of these sketches, make or cause to be made, any models for Mr. Edison of features shown in some of these
sketches? 148

A. Yes, sir.

Q. 67. Do you know whether those models are in existence or not; if so, where are they?

A. I think they are at Menlo Park.

Q. 68. Will you make search for them, so that they may be put in testimony?

A. Yes, sir, I will.

Q. 69. I now hand you a sketch and ask you to read what is written at the top of the same?

149 A. "Scale 1 in. pr. ft., Edison's Electric Tramway, May 18th, 1879."

Q. 70. In whose handwriting is this?

A. In my own.

Q. 71. By whom was this sketch made, and at what time?

A. It was made by me, May 18th, 1879.

Q. 72. Was it made under the direction of anybody, and if so, who directed it?

A. Mr. Edison directed it.

150 Q. 73. Is it simply a sketch, or a working drawing?

A. It is a working drawing.

Q. 74. What does the left hand figure represent?

A. It represents a front end view of an electric locomotive, and the trestle supporting the railroad track.

Q. 75. What kind of an electro motor is shown in that figure?

A. One of Edison's dynamo machines in a hori-
151 zontal position, with the cast iron poles to the front.

Q. 76. How is that dynamo supported in the locomotive?

A. There are two brackets bolted to one of the cast iron poles, which answer as the bearings of the front axle, which is the armature shaft at the same time.

These two brackets support the whole front part of the dynamo machine.

Q. 77. How was motion imparted to the driving
152 wheels by the revolution of the armature?

A. The armature was fast to the axle by means of feathers.

Q. 78. What is shown in this figure immediately to the left of the amature?

A. The commutator.

Q. 79. What is shown on the right upper portion of the figure?

A. The ball spring governor.

Q. 80. What is the office of the bracket or arm shown at the top of the figure?

A. It is the support and bearing for the governor 153
shaft.

Q. 81. What sort of railroad rails are shown in this figure?

A. Strap rails.

Q. 82. How secured in position?

A. They are screwed down on to the longitudinal sleepers.

Q. 83. And how are these sleepers secured to the trestle work?

A. By square headed bolts with nuts, counter- 154
sunk.

Q. 84. Now describe the figure to the right on the drawing?

A. The figure to the right shows the electric locomotive, car, trestle and rails from the side.

Q. 85. Is it the same as that shown in the left hand figure in front view?

A. It is the same, with the car attached.

Q. 86. How was circuit connection made between
the locomotive and the electric conductors? 155

A. By means of rollers or brushes shown to the right and left on the left hand figure, fastened to the brackets supporting the machine. On the right of this figure is a lever shown, which in connection with the governor, will break or make contact with the copper rods which are shown on the right and left, fastened to the right and left of the longitudinal sleeper.

Drawing referred to put in evidence and 156
marked "Edison's Exhibit No. 8."

Q. 87. I show you a paper containing figures and rough sketches in pencil, and ask you when the same was made and by whom, and for what purpose?

A. It was made about the same time as the sketch marked "Edison's Exhibit No. 8." It was made by me and is an estimate of the cost of such a railroad with equipments, per thousand feet.

Q. 88. At whose request, if any person's, was this estimate made?

157 A. It was made at Mr. Edison's request.

Paper referred to put in evidence and marked "Edison's Exhibit No. 9."

Q. 89. Please examine this sketch which I now hand you, and read what is written at the top of it?

A. "Scale 2 inch to 1 ft. May 24th, 1879. J. K. Electric Tramway."

Q. 90. By whom was this sketch made and at
158 what time, if you know?

A. It was made by me on the date marked upon it.

Q. 91. If made by or under the direction of any person, state whom?

A. Under the direction of Mr. Edison.

Q. 92 Is this a sketch or a working drawing.

A. It is drawn to scale, and can be used as a working drawing.

Q. 93. What does it represent?

159 A. It represents the front-end view of an electric locomotive.

Sketch put in evidence and marked "Edison's Exhibit No. 10."

By consent, the taking of further testimony was postponed to Friday, November 18th, 1881, at 10 A. M., at same place.

WM. H. MEADOWCROFT,
Notary Public,
160 New York County.

Pursuant to adjournment the taking of testimony was continued on Friday, November 18, 1881, at ten o'clock A. M., the same counsel being present.

Q. 94. Wherein, if at all, does this sketch differ from that shown in the left-hand figure of Exhibit No. 8?

A. It is twice the size, and differs somewhat in the construction of the governor. The governor is

not as near completed in No. 10 as it is in the left- 161
hand figure of No. 8. The contact arrangement shows more plainly on the left of Exhibit No. 10 than it does in Exhibit No. 8. The commutators and brush are shown plainer in Exhibit No. 10 than they are in Exhibit No. 8.

Q. 95. Please examine the sketch I now show you and read what is written on the upper part of the same?

A. "Strap r. ½" × 2" copp. w s, ¼". E. Tramway, May 24th, 1879. J. Kruesi." 162

Q. 96. By whom was this sketch made, and when, if you know?

A. It was made by me on the date it bears—May 24th, 1879.

Q. 97. Was this sketch made under the direction of any person; if so, whom?

A. It was made under the direction of Mr. Edison.

Q. 98. Please to describe, fully and carefully, what this sketch illustrates? 163

A. It illustrates the front view of an electric locomotive on a railroad track. It shows the general construction.

Q. 99. What kind of rails appear as the track in this sketch?

A. The rails that are shown on the track are what are called T-rails.

Q. 100. How were the wheels shown in that sketch to be constructed, or what kind of wheels were they to be? 164

A. The wheels were to be paper wheels, with a metallic rim.

Q. 101. What means were employed, if any, to conduct electricity along the line of the railroad?

A. There were two ways proposed—one to use the rails as conductors, the other to use the rails for one conductor, and a copper rod for the other. It was, however, later on, decided to use the rails as conductors.

165 Q. 102. Is this sketch provided with a commutator, also a governor?

A. Yes; there is a commutator and two differently applied governors.

Q. 103. In this sketch current being applied to the locomotive, how would the wheels be turned?

A. By means of the force of the armature which is fast to the axle of the wheels.

Sketch put in evidence and marked "Edison's Exhibit No. 11."

166 Q. 104. Did you make search for the models at Menlo Park, that were referred to last evening?

A. I have done so, and I now produce them.

Q. 105. Where did you find these models?

A. I found them in the office which I occupied during my engagement with Mr. Edison at Menlo Park.

Q. 106. What does this model which I now hand you represent?

167 A. It represents a railroad track and trestle.

Q. 107. Who made the model?

A. One of my workmen, under my direction.

Q. 108. At what time?

A. On the date it bears; May 25th, 1879.

Q. 109. If there is a paper pasted on the model, containing writing, read the writing.

A. "Edison's Electric Tramway, made May 25th, 1879, Chas. Batchelor, John Kruesi."

Q. 110. Who wrote "John Kruesi" on that
168 paper?

A. I wrote it myself.

Q. 111. Please state whose handwriting appears on the paper?

A. Mr. Charles Batchelor's and my own. Mr. Batchelor wrote the following words: "Edison's Electric Tramway, made Chas. Batchelor."
I wrote "May 25th, 1879; John Kruesi."

Q. 112. Did you have this model made under anybody's directions; if so, whose?

A. I had it made under Mr. Edison's directions. 169

Model put in evidence and marked "Edison's Exhibit No. 12."

Q. 113. Please examine the model I now show you; state what it is?

A. It is a model of a railroad track, supported on trestles.

Q. 114. When was it made, and under whose directions?

A. It was made on the date it bears, or before; 170
May 25th, 1879: under my directions.

Q. 115. Did you have directions from anybody to have it made?

A. Yes, sir; from Mr. Edison.

Q. 116. If there is a paper on this model with writing upon it, read the same, and state in whose handwriting it is?

A. "Edison's Electric Tramway, made May 25th, 1879, Chas. Batchelor, John Kruesi." The following
words are in Mr. Batchelor's handwriting: "Edi- 171
son's Electric Tramway made," "Chas. Batchelor." The rest if in my own; namely, "May 25th, 1879, John Kruesi."

Model put in evidence and marked "Edison's Exhibit No. 13."

Q. 117. Please examine the model I now show you; state what it is.

A. It is a model of a railroad track supported by trestle work. 172

Q. 118. When was it made, and under whose directions?

A. Mr. Edison directed me to have it made on or before May 25th, 1879.

Q. 119. If there is a paper on this model with writing upon it, read the same, and state in whose handwriting it is.

A. "Edison's Electric Tramway, made May 25th, 1879. Chas. Batchelor, John Kruesi."
The following is in Mr. Batchelor's handwriting: "Edison's Electric Tramway made," "Chas.

173 Batchelor." The rest, "May 25th, 1879," "John Kruesi," is in my own handwriting.

Model put in evidence and marked "Edison's Exhibit No. 14."

Q. 120. Did you make a full sized trestle like one of those shown in exhibits you have presented, and if so, like which one; and when was it made, and under whose directions?

A. I had one made like Exhibit No. 12 a short
174 time after this exhibit was made. It was directed by Mr. Edison.

Q. 121. Where is that trestle now?

A. It is at Menlo Park. It may not be in complete order at present.

Q. 122. Do you know the reason which influenced Mr. Edison to change his electric railway plans of using a flat or strap rail, and using in preference the T rail?

A. One of the reasons was that Mr. Edison feared
175 that the copper rods would in unprotected, unpopulated countries be stolen away, which, of course, would cause continual interruptions. By carefully estimating it was found that the extra cost of T-rails over flat rails would be nearly balanced by doing away with the copper conductors.

Q. 123. Do you know if Mr. Edison, in May, 1879, had any method of connecting the meeting ends of the T-rails, so as to make them better conductors; if so, what was that method?

176 A. The method was to lay a piece of brass or copper under the fish plates, through which the bolts would pass, or using copper wire in the same manner.

Q. 124. Did you have charge of the mechanical part of the construction and setting up of Mr. Edison's electric locomotive in the spring of 1880?

A. Yes, sir.

Q. 125. Do you remember about the dates when that was done?

A. In April, 1880.

Q. 126. When did you see that electric locomotive last, and where? 177

A. I saw it last last night, at Menlo Park, N. J.

Q. 127. Did you examine it particularly, at my request?

A. Yes, sir.

Q. 128. How did you find the construction and arrangement of the various operative parts to correspond with those of the locomotive when it was first built?

A. I found no material change or difference except in the driving gear. 178

Q. 129. What change has been made in the driving gear from the locomotive as first built?

A. The first built had friction gears to transmit movement or motion, while at present motion is transmitted by belts.

Q. 130. Do you know how long these first friction gears were in the locomotive; if so, state it?

A. They were only in until the first trial was made, which may have been the latter part of May, 179
1880.

Q. 131. After the belt driving gears were put in the locomotive was the locomotive put into use?

A. Yes, sir.

Q. 132. On what kind of a track and how long a track, and how frequently?

A. On a T-rail track about half a mile long. It was used almost every day for a period of four or five months.

Q. 133. What rate of speed was attained by the locomotive? 180

A. The half mile trip was made in from eighty to ninety seconds. Some parts of the distance were made at the rate of forty to forty-five miles an hour.

Q. 134. What was the source of the electric current?

A. Mr. Edison's dynamo machines?

Q. 135. Where were they placed?

A. In his machine shop, at Menlo Park.

181 Q. 136. How was the current transmitted from the dynamo machines along the line of the railway?

A. By copper wires from the dynamo machines to the first iron rails, and from there the rails were the conductors.

Q. 137. How did the electric current get from the rails into the locomotive?

A. Through the rims of the wheels; from them to a hub of composition; then through brushes and wires to the respective parts of the dynamo ma-
182 chine.

Q. 138. How did the electric current get out of the locomotive?

A. The same way as it got in, on the other side of the locomotive, connected to the other rail.

Q. 139. If, at any time, this belt driving gear was taken out of the locomotive, what was substituted for it?

A. Cog-wheels.

Q. 140. Do you remember when this was done?
183 A. It was done in the Fall of 1880.

Q. 141. Do you know why it was done; if so, state it?

A. It was done to produce a more powerful machine at the expense of speed.

Q. 142. Do you know how much use was made of the locomotive with this cog gearing?

A. It was only used three or four times for short experiments.

Q. 143. Was it used long enough to demonstrate
184 the practicability of such gear for the purpose designed?

A. It was used long enough to show the practicability of the system if the parts were made properly.

Q. 144. Do you know where that cog gear is now?

A. They are at Menlo Park.

Q. 145. Did you superintend the making of it?

A. Yes.

Q. 146. Has there been any change made in it 185
since its construction? if so, what?

A. There have been no changes but repairs.

Q. 147. Can the cog gear in that locomotive be substituted for the belt-driving gear or the belt-driving gear be substituted for the cog gear without affecting the integrity of the machine? I mean by that without dismantling the machine and taking it all apart.

A. Either gear can be put in or taken out without
taking the machine completely apart and without 186
taking the machine off the rails.

Q. 148. How long a time would be required for substituting one form of gear for the other in that locomotive?

A. About half a day.

Q. 149. When did you leave Menlo Park? I mean quit working there.

A. February 26th, 1881.

Q. 150. How frequently have you been there
since? 187

A. I lived out there until the first of this month and frequently visited the laboratories and shops of Mr. Edison in the evenings and Sundays and did some work there sometimes.

CROSS-EXAMINATION BY F. W. WHITRIDGE, ESQ., OF COUNSEL FOR FIELD:

x-Q. 151. Were you employed by Mr. Edison at Menlo Park uninterruptedly during the years 1878, 1879, and 1880, as you have testified?
A. Yes, sir. 188

x-Q. 152. What was the scope of your duties?

A. I was foreman of the mechanical department.

x-Q. 153. All of the models and machines were made in that department under your direction?

A. Yes, sir.

x-Q. 154. About how often did you see Mr. Edison?

A. Sometimes once a day; sometimes five or six or more times a day.

189 x-Q. 155. Did you make no models of any of Mr. Edison's inventions during this time to which you yourself contributed some of the elements?

A. I don't understand the question.

x-Q. 156. Were your instructions from Mr. Edison in constructing models usually oral or written?

A. Usually verbal, but very often written.

x-Q. 157. Were any of those written directions preserved?

A. I do not know. They are not in my possession
190 if there are any.

x-Q. 158. Was it your habit to preserve those instructions while you were foreman?

A. I used to keep them generally for the duration of an experiment, after which I turned them over to the office.

x-Q. 159. Do you know what the office did with them?

A. They were stored away.

x-Q. 160. And preserved?

191 A. Yes.

x-Q. 161. Can you fix a little more definitely the time when Mr. Edison started on his trip out West in 1878, as to which you have testified?

A. Not from memory, but I could find out from memorandum books.

x-Q. 162. How long was he gone, do you know?

A. He was away about six weeks, I believe.

x-Q. 163. Do you know where he went—how far West?

192 A. To California.

x-Q. 164. Do you know how long he was in California?

A. I think he was about three weeks in California and the neighboring States.

x-Q. 165. Can you give the date of your conversation with him upon the subject of electrical railways, after his return?

A. No, I cannot fix the date.

x-Q. 166. About how long was it after he got back?

A. I cannot tell what time after, as he very often 193
related what he had seen and thought and done on his trip, and it was generally done at times when everybody was too tired to keep on working, which helped to cheer up the men to go to work again.

x-Q. 167. His account of his conception of his electric railway, which would pay in wheat growing States, was just one of his cheering accounts, was it?

A. It was one of them.

x-Q. 168. Do you recollect any one particular con- 194
versation in which he spoke, of this or was it scattered through several?

A. It was scattered through several conversations, which remain in my memory pretty well, because he put me to work in the spring of '79 to estimate for such a railroad with equipments, for the purpose then mentioned.

x-Q. 170. Did the cheering effect of these accounts of Mr. Edison's conception of the electric railway lie
in the thought of an electric railway, or in the 195
thought that it would pay in wheat growing States?

A. I do not remember exactly the effects of the particular accounts in regard to cheering.

x-Q. 171. You cannot fix more definitely the time after his return from the West, when he first began to cheer you with his conception of the electric railway?

A. No.

x-Q. 172. Where was Exhibit No. 1 drawn?

A. At my office at Menlo Park. 196

x-Q. 173. At what time?

A. I believe, May 18th, 1879, or before.

x-Q. 174. Can you not fix the day positively?

A. Not without the aid of an almanac of that year. I remember it was on a Sunday—either that date or the nearest Sunday before it.

x-Q. 175. What time of day was it made?

A. In the forenoon.

x-Q. 176. Did you see Mr. Edison make the whole of it?

197 A. I believe I him saw make all of it ;I am not aware that anything was put on after I saw him drawing it.

x-Q. 177. When was Exhibit No. 2 made?

A. The same day as Exhibit No. 1.

x-Q. 178. How long after it was made did you mark it ?

A. That I do not remember; I suppose right after.

x-Q. 179. Do you recollect marking it that day?

198 A. No; but I know I was in the habit of marking all sketches that Mr. Edison made as soon as he laid them down.

x-Q. 180. Do you remember what the letters "E. L." are, at the top, which have been erased?

A. I suppose it was a mistake in marking.

x-Q. 181. You don't know what it means?

A. I think it stands for "Electric Light," and was probably marked on the sketch by mistake. "E. L." on sketches usually stands for "Electric
199 Light."

x-Q. 182. Did you mark it immediately after he made it?

A. I may not have marked it immediately after it was made, but I dated it on the day it was made.

x-Q. 183. Do you think that all the writing upon it was done by you at the same time?

A. I am not certain of that.

x-Q. 184. Will you please look at it and see if you
200 think the writing upon it looks as if it was all done at the same time?

A. I can't tell whether it was all done at the same time.

x-Q. 185. Is it all your handwriting?

A. Yes.

x-Q. 186. If it was all written at the same time it would probably have been written by the same pencil, would it not?

A. Well, it isn't safe to conclude thus, as I may have had two or more pencils on hand.

x-Q. 187. Please look at Exhibits Nos. 2, 3, 4 and 201
5, and state whether "May 18th" and the rest of the writing upon them now appears to you to have been written with the same pencil at the same time upon each.

A. It appears to me that the dates were all written at the same time with the same pencil, and the rest of the writing with another pencil.

x-Q. 188. Was Exhibit No. 2 made by Mr. Edison on the same Sunday morning on which he made Exhibit No. 1?

A. Yes, sir. 202

x-Q. 189. How long was he making these two sketches 1 and 2?

A. I can't tell how many minutes. He is very quick in making sketches of that kind.

x-Q. 190. Please look at Exhibits Nos. 2 and 3, and state whether the initials are the same upon each?

A. They do not appear the same, but I recognize them as my handwriting. 203

x-Q. 191. Have you any recollection of when you marked Exhibit No. 3?

A. No, I have no distinct recollection.

x-Q 192. You fix the date by the date which is marked upon the paper only, I understand?

A. Yes, sir.

x-Q. 193. Will you please point out on Exhibit No. 4, the handwriting of Mr. Edison, by which you testified that you recognized it?

A. By the words "same here." 204

x-Q. 194. Have you ever known Mr. Edison to write upon the sketches made by other persons than himself?

A. I do not recollect any drawing or sketch not made by him that he wrote on.

x-Q. 195. Did he, to your knowledge, ever write upon any sketches or drawings made by you?

A. He may have written some remarks on my or other drawings, but I do not remember any such instance.

205 x-Q. 196. In dating these sketches at Menlo Park, were dates fixed to them at Mr. Edison's direction?

A. Some of his employees were requested to date the drawings and sketches, and sign them.

x-Q. 197. In such cases, the dating would be merely a dictation from Mr. Edison, would it not?

A. It was a general dictation which was not given for any special or particular drawing or sketch, but the order was in general to date all sketches and all drawings that were made there on the day they
206 were made, or in case it was neglected to put the date down on the day the sketch was made, to put down the date of the day when they were dated.

x-Q. 198. Did you ever know of a drawing which was not dated when it was made, to subsequently have been marked with the date of making?

A. I do not remember any particular drawing, but am aware of cases where it was neglected and put on afterwards.

x-Q. 199. How far do you know that Exhibit No.
207 7 was made upon the same day as Exhibit No. 6?

A. I only judge from the relation of the two drawings.

x-Q. 200. You do not remember that Mr. Edison told you that such was the fact?

A. No.

x-Q. 201. Do you remember when Exhibit No. 6 was marked?

A. I do not distinctly remember.

x-Q. 202. You don't remember the day of the
208 week?

A. No.

x-Q. 203. Nor the time of day?

A. No.

x-Q. 204. In your explanation of what you understand Exhibit No. 1 to represent, how do you know what the word "shaft" is intended to mean.

A. The two lines between which the word "shaft" is written indicate to me that they are meant to represent the belt which necessarily has to come from a shaft.

x-Q. 205. Your general knowledge as a mechanical engineer enables you, I understand, to state what is thus intended? 209

A. Yes, sir.

x-Q. 206. Please look at Exhibit No. 4, and state why you think it represents a current reverser?

A. From my general knowledge of Mr. Edison's devices.

x-Q. 207. When was Exhibit No. 8 made.

A. It must have been made on the date which it bears, as I recollect making it myself. 210

x-Q. 208. How long did it take you?

A. I do not recollect, but should judge about half a day.

x-Q. 209. Do you remember the day of the week?

A. No; I do not.

x-Q. 210. Was it the same day on which you saw Exhibits Nos. 1 and 2, drawn by Mr. Edison?

A. I think it was the same day.

x-Q. 211. That, I understand you to have testified, was on Sunday?

A. Yes. 211

x-Q. 212. You have, however, no recollection, I understand you, of making it?

A. Yes, sir; I have recollection of making it, but what I do not recollect is the hour or the day of the week.

x-Q. 213. Are you sure that it was made upon the same day as Nos. 1 and 2?

A. Yes; I am sure on account of the date.

x-Q. 214. Did you make it before or after? 212

A. After; because Exhibits 1 and 2 served as explanations for No. 8, or as a basis to work upon.

x-Q. 215. Do you remember when you made Exhibit No. 9?

A. I remember that I made it shortly after No. 8.

x-Q. 216. Can't you fix the time any more definitely?

A. I cannot fix it definitely. I only remember that I estimated the probable cost of 1,000 feet of such a road about that time.

213 x-Q. 217. How long after Mr. Edison directed this estimate to be made did you make it?

A. I cannot define the time.

x-Q. 218. Do you remember what he said when he told you to make such an estimate?

A. After he had a rough idea of the construction of such a locomotive and track, he directed me to estimate the probable cost of a thousand feet of such a road as the drawings produced here indicate.

x-Q. 219. What is that building shown on Ex-
214 hibit No. 6, intended to represent?

A. As near as I remember, he intended it to show a railroad station when the dynamo machines were run by a wind mill.

x-Q. 220. Did you ever have any conversation with Mr. Edison about running the dynamos by wind power?

A. I remember discussing the matter.

x-Q. 221. Was it suggested, so far as you can remember, that such a means of generating power was
215 especially suitable to these wheat growing regions, in which the railroad was conceived, as I understand you?

A. No; I think it was suggested for the use of such a railroad in the far West, in the mining countries.

x-Q. 222. Do you remember which of your workmen made those models, Exhibits 10, 11 and 12?

A. By Milo P. Andrews.

216 x-Q. 223. Where is he?

A. He resides at Menlo Park.

x-Q. 224. Do you remember when they were made?

A. Yes; I remember that they were made right after I had sketches made, and from sketches received from Mr. Edison, which are those introduced as exhibits.

x-Q. 225. Do you remember if any of these papers were ever given by you to this workman Andrews?

A. No; I do not remember; I do not think they 217
were, as there is no measurement on them, which I had to furnish to Mr. Andrews for making these models.

x-Q. 226. Do you remember what drawings, if any, were made by Mr. Hornig?

A. Yes; I remember that he made drawings for the electric locomotive, which we made afterwards.

x-Q. 227. Was the electric locomotive made from his drawings, or from these of yours? 218

A. It was made from his drawings.

x-Q. 228. Do you know what has become of these drawings?

A. I believe they are in charge of the Engineering Department of the Edison Electric Light Company.

x-Q. 229. What became of these drawings of yours after they were made?

A. I handed them into the office at Menlo Park.

x-Q. 230. Do you know what use, if any, was 219
made of them?

A. No; I do not.

x-Q. 231. Do you remember when it was decided to give up the copper rod or wires of which you have spoken, and to use only the rails as conductors?

A. About the time between the 18th and 24th of May, 1879.

x-Q. 232. That was the final decision, was it, so
far as you know? 220

A. As far as I know it was.

x-Q. 233. What change was made in the locomotive between the time when you last saw it, previous to yesterday, and yesterday, other than that of the gearing apparatus which you have been mentioned.

Objected to by counsel for Edison as not a correct statement of the testimony, as witness has nowhere stated that there has been any

221 change in the gearing of the locomotive between the two times when he last saw it. Question withdrawn.

x-Q. 234. What change, if any, was made in the locomotive between the time when it was first completed and yesterday when you saw it, other than that of the gearing apparatus.

A. There were only changes made in the woodwork for seats for the engineer and brakeman; changes of the brakes; and changes of the connect-
222 ing wires necessitated by the changing of the woodwork.

x-Q. 235. How long was the first gearing apparatus, by means of friction wheels, used?

A. It was in the machine perhaps four days, running perhaps an hour or two.

x-Q. 236. Why and when was it taken out?

A. It broke by an accident, and was taken out the same day.

x-Q. 237. What was the occasion of the accident?

223 A. The engineer threw in the gears too suddenly.

x-Q. 238. Was it replaced?

A. No, the driving gear was changed immediately into belt driving gears.

x-Q. 239. How did a different kind of gear come to be substituted after this accident?

A. Because it would have taken too long to replace the first, and Mr. Edison wanted to use the locomotive right off.

x-Q. 240. What kind of belting was used in this
224 new gearing apparatus?

A. Double leather belts.

x-Q. 241. How long was this apparatus used?

A. The first belts, pulleys and shafts were put on quickly, gathered up in the shop, and were not put on in such a manner as to make them permanent. They were replaced afterward by more solid and permanent hangers of the same kind.

x-Q. 242. When was the cog or tooth gearing substituted?

A. In the fall of 1880.

x-Q. 243. Do you know why it was substituted? 225

A. For the purpose of converting the same machine into a slow-running, powerful machine for a steep inclined railroad.

x-Q. 244. How long was that used?

A. It was used a short time only.

x-Q. 245. What were the repairs to the cogs of which you have spoken?

A. The repairs were to the friction clutches.

x-Q. 246. What was the nature of those repairs?

A. They were not made exactly right in the first 226
place, and had to be altered to suit the other parts of the machine.

Cross-examination by Charles S. Whitman, Counsel for Siemens.

x-Q 247. You state in answer to Question 1 that your occupation is that of Treasurer for the Electrical Tube Company. What was your occupation prior to holding that office?

A. I was foreman of the mechanical department 227
of Mr. Edison's laboratory at Menlo Park.

x-Q. 248. How long were you in Mr. Edison's employ?

A. Nine years.

x-Q. 249. Do you mean for the nine years immediately preceding the time you entered the employment of the Electrical Tube Company?

A. Yes, sir.

x-Q. 250. When and where did you first become acquainted with Mr. Edison.

A. In the spring of 1871, in Newark, N. J. 228

x-Q. 251. What was your occupation before going into Mr. Edison's employ?

A. I was tool maker in Singer's needle factory.

x-Q. 252. Are you a mechanical engineer by profession?

A. I am a machinist by profession.

x-Q. 253. Where were you born, Mr. Kruesi?

A. In Switzerland.

229 x-Q. 254. You speak and read the German language, do you not?

A. Yes, sir.

x-Q. 255. How long have you been in this country?

A. Within one month of eleven years.

x-Q. 256. When did you last visit Europe?

A. I have never been back to Europe since I arrived in this country.

x-Q. 257. Have you ever been called upon by Mr.
230 Edison to act as an interpreter or to make translations from German or any foreign language into English?

A. I have sometimes translated letters and newspaper articles.

x-Q. 258. Do you remember now any particular newspaper articles that you ever had occasion to translate for Mr. Edison?

A. I do not remember any particular ones.

x-Q. 259. Why did Mr. Edison require newspaper
231 articles to be translated?

A. They were foreign newspapers which were sent to him, which contained articles which the senders thought would interest him.

x-Q. 260. Do you remember the names of any of these newspapers from which you translated articles?

A. No; I do not remember their names.

x-Q. 261. Do you remember ever to have translated for him an article or articles contained in
232 newspapers or periodicals printed in German or any other foreign language in this country?

A. Yes.

x-Q. 261A. Please give the name of such newspaper?

A. The "New York Staats Zeitung," "Beletristisches Journal" and Pittsburg "Freiheits Freund;" that's all I can remember.

x-Q. 261B. Give the names, if you can, of the journals of which you have spoken as they would be rendered in English?

A. "New York State Gazette," "Belles Lettres 233
Journal," "Pittsburg Friend of Liberty."

x-Q. 262. Are you a subscriber for these papers?

A. I have been a subscriber for the first two named.

x-Q. 263. How long since you were a subscriber for the first two named?

A. For the "Staats Zeitung," off and on until last spring; the "Beletristisches Journal" I had for one year; I believe it was 1877.

x-Q. 264. Were you a subscriber of any of the 234
papers named during the years 1879 and 1880?

A. I believe I was for the "New York Staats Zeitung" during both years; for no other.

x-Q. 265. Please state as nearly as you can what German papers or periodicals you remember to have read during the years 1879 and 1880?

A. The N. Y. Staats Zeitung, the Techniker and occasionally papers that were sent to me, of which I can only remember the names of two—the
Pittsburg Freiheits Freund and, I think, the other's 235
name is Volksfreund, printed also in Pittsburg.

x-Q. 266. Are any of the papers of which you have spoken devoted to scientific or mehanical subjects?

A. Yes; the Techniker.

x-Q. 267. As the Techniker relates to your profession, I suppose you were in the habit of reading it pretty regularly during the years 1879 and 1880, were you not?

A. No; as before stated I only read it occasionally? 236

x-Q. 268. Do you remember to have translated for Mr. Edison any articles from the papers of which you have spoken?

A. I believe I did translate one article which was bearing upon electric light.

x-Q. 269. From what paper was that article upon electric light taken?

A. From the Techniker.

x-Q. 270. Do you remember the month and year in which the Techniker containing the article upon the electric light was published?

237 A. I think it was in 1880, but I do not remember the month.

x-Q. 271. What electric light was described in that article in the Techniker?

A. Edison's.

x-Q. 272. Was the article an illustrated article?

A. I think it contained an illustration of Edison's incandescent lamp.

x-Q. 273. Do you remember to have translated any other article from the Techniker for Mr. Edison?

238 A. No; I do not remember any other.

x-Q. 274. Does Mr. Edison subscribe for the Techniker or any other German publication which you have mentioned?

A. No; not to my knowledge.

x-Q. 275. Where did you obtain the paper called the Techniker from which you made the translation for Mr. Edison?

A. I got it from a man whose name is Holzer.

x-Q. 276. Who is Mr. Holzer, what is his
239 occupation and where does he live?

A. His occupation is glassblower and he lives at Menlo Park.

x-Q. 277. Is he in Mr. Edison's employ, and if so, for how long has he been in his employ?

A. I think he has been in his employ since January, 1880.

x-Q. 278. Does Mr. Holzer subscribe for the Techniker?

A. I think not.

240 x-Q. 279. Do you know of anybody else in Mr. Edison's employ who now subscribes for the Techniker, or who did so subscribe in 1879 and 1880?

A. I do not know of anybody.

By consent the taking of further testimony was postponed to Monday, November 21st, 1881 at 10 o'clock A. M., at same place.

Wm. H. Meadowcroft,
Notary Public,
New York Co.

Pursuant to adjournment, the taking of testimony was continued on Monday, November 21, 1881, at same place, the same counsel being present. 241

x-Q. 279. In making the figures and drawings shown on Exhibits Nos. 8, 9, 10 and 11, did you receive any assistance or instructions from a person or persons who had seen Siemens' electric railway in operation at Berlin, Dusseldorf or Brussels?

A. No. I have not received any instructions or assistance from anybody except Mr. Edison.

x-Q. 280. When Mr. Edison gave you the instructions to make Exhibits Nos. 8, 9, 10 and 11, did he 242
inform you that the apparatus which he desired illustrated was the same as that which had been reduced to practice and put in successful operation by Siemens at Berlin?

A. No, he did not.

x-Q. 581. What, if anything, did he state to you with regard to the Siemens' electric railway?

A. I don't remember that he spoke of the Siemens' electric railway about the time that these ex- 243
hibits 8, 9, 19 and 11 were made.

x-Q. 282. At what time, then, did he speak of the Siemens' electric railway to you?

A. As far as I remember, it was some time after, when I mentioned that I was reading about Siemens' electric railway in some paper.

x-Q. 283. What did he say to you when you mentioned your reading of the Siemens' electric railway in some paper?

A. I don't remember much of what he said. I 244
think he mentioned that Siemens's electric railway would not answer for the purpose that he designed his for.

x-Q. 284. Did he state the reason for which it would not answer the purpose for which he had designed his?

A. I do not recollect whether he did or not.

x-Q. 285. What else did he say to you concerning the Siemen's electric railway?

A. I don't remember anything about this conver-

245 sation on Siemens' electric railway, except when it
was mentioned to him and we had our railroad
going, that Siemens was using the rails as one part
of the circuit, and a separate conducter for the
other part, and he said that he didn't see any trouble
in using the rails alone.
x-Q. 286. What did Mr. Edison mean by stating
that Siemens's railway would not answer his pur-
pose? Did he mean the purposes of transmitting
grain—the far .1 purposes of which you have here-
246 tofore spoken.
A. I don't remember whether he explained the
matter or not. I don't know what he meant.
x-Q. 287. If you did not understand Mr. Edison's
remark to you, why did you not ask him what he
meant?
A. I don't know; perhaps it was lack of time.
x-Q. 288. Are you not generally in the habit of
endeavoring to understand remarks made by Mr.
Edison to you?
247 A. Yes, I generally endeavor to understand, but
we both were often very busy, so that I was satis-
fied with a short answer.
x-Q. 289. What were you so busy about at that
time?
A. There were two or more experiments going on
at the same time, and they all required our atten-
tion.
x-Q. 290. State what these two or more experi-
ments were?
248 A. Electric light and telephone.
x-Q. 291. When did you commence the experi-
ments on the electric light to which you have just
referred?
A. The summer of 1878.
x-Q. 292. When did you commence the experi-
ments on the telephone to which you have just re-
ferred?
A. I think it was in the fall of 1875.
x-Q. 293. You speak of "two or more" experi-
ments. Were you experimenting on anything else

beside the electric light and telephone at the time 249
when you were so busy that you did not endeavor
to understand what Mr. Edison meant when he
stated to you that the Siemens railway would not
answer his purpose?
A. I answered "two or more," because I was not
sure that there were only two, and do not remember
what the others were, if there were any.
x-Q. 294. What particular work upon the electric
light or telephone were you engaged on when Mr.
Edison informed you that the Siemens' electric rail- 250
way would not answer his purpose?
A. I do not recollect.
x-Q. 295. Where were you when Mr. Edison in-
formed you that the Siemens' electric railway would
not answer his purpose.
A. At Menlo Park.
x-Q. 296. At what part of Menlo Park?
A. I do not remember the particular spot I stood,
but it was inside of his establishment there, as near
as I can remember. 251
x-Q. 297. Did you show Mr. Edison the paper
from which you read the descriptions of the Siemens'
electric railway?
A. I don't think I did; I don't remember.
x-Q. 298. Did you have the paper with you when
you gave him the information concerning the Sie-
mens' electric railway?
A. I do not recollect.
x-Q. 299. Do you recollect whether you read to
him the article in the paper, or informed him of the 252
article concerning the Siemens' electric railway?
A. No; I do not recollect.
x-Q. 300. Do you recollect whether Mr. Edison
asked you to procure that paper for him?
A. No; I do not.
x-Q. 301. Where did you obtain the paper from
which you read the article concerning Siemens' elec-
tric railway?
A. I don't remember.

253 x-Q. 302. Have you what is considered a good memory?

A. I think it is variable. Some things remain a long while, and others I forget right away.

x-Q. 303. What became of the paper from which you read the article concerning Siemens' electric railway?

A. I don't know.

x-Q. 304. When did you last see that paper?

A. I don't know.

254 x-Q. 305. Was the paper a scientific paper or an ordinary daily newspaper?

A. I don't remember.

x-Q. 306. Do you remember whether the paper contained any illustrations?

A. I don't remember to have seen any illustration of the Siemens' electric railway.

x-Q. 307. In what year was it that this conversation occurred between you and Mr. Edison concerning Siemens' electric railway?

255 A. I think it was in 1879.

x-Q. 308. What kind of weather was it when the conversation occurred, cold or warm?

A. I think it was in warm weather, as I consider spring, summer, and fall warm weather, and only winter cold.

x-Q. 309. What reason have you for thinking it was warm weather when the conversation occurred between you and Mr. Edison concerning the Siemens electric railway?

256 A. For the reason that the winter was just over when I was first engaged in the experiment, and that I do not recollect to have been engaged in the experiment again during the winter following.

x-Q. 310. What experiments do you refer to?

A. The electric railroad experiment.

x-Q. 311. I understand you to state that it was in the year 1879, in warm weather, immediately after the winter, when you had the conversation with Mr. Edison concerning Siemens's electric railway; is this correct? 257

> Counsel for Edison objects to the question on the ground that it pre-supposes a statement that the witness has nowhere made, namely, that the conversation took place immediately after the winter.

A. I answered that, I think it was in warm weather. It might have been spring, summer, or fall.

x-Q. 312. What do you mean by experiments concerning the electric railway in your answer to question 310? 258

A. I understand all the work done for an invention until the same is complete for practical use to be experimental—it may be drawing, machine work, blacksmith work, or carpenter work.

x-Q. 313. Was any machine work, blacksmith work, or carpenter work done on the electric railroad of Mr. Edison in 1879, if so, what?

A. There was some carpenter work and some machine work on the models, Exhibits 12, 13, and 14. 259

x-Q. 314. Was there any other carpenter work, machine work, or blacksmith work done upon the electric railroad of Mr. Edison during the year 1879, except that done upon the exhibits of which you have just testified?

A. Yes, there was a full sized model of the trestle made on which there was some carpenter work, blacksmith work, and machine work done. 260

x-Q. 315. Where is that model of the trestle of which you speak?

A. I think some parts of it can be found at Menlo Park around the laboratory of Mr. Edison.

x-Q. 316. What time during the year 1879 was the model of the trestle made of which you have just testified?

A. I think it was about June or July.

261 x-Q. 317. Was any model made of the electric locomotive of Mr. Edison during 1879.

A. I think there were some Patent Office models made, but I am not sure, though.

x-Q. 318. What reason have you to think that any Patent Office models were made in 1879?

A. I think I remember that they were made in the shop, but I am not sure.

x-Q. 319. What particular experiment concerning the electric railway were going on at the time you
262 described Siemens's electric railway to Mr. Edison?

A. I don't remember.

x-Q. 320. Give as nearly as you can the language which you used in describing Siemens's electric railway to Mr. Edison.

A. I stated that I read in some paper that Siemens had an elevated electric railway in experimental operation at Berlin. That's as near as I can remember.

x-Q. 321. State as nearly as you can all the con-
263 versation that occurred between you and Mr. Edison at that time, concerning the Siemens electric railway?

A. I don't recollect Mr. Edison's answer any more than that he answered as I stated before, to the effect that Siemens' system of electric railway would not answer his purpose.

x-Q. 322. Did any one who had seen publications describing Siemens', electric railway, assist you in the preparations of the drawings shown in Exhibits 8,
264 9, 10 and 11?

A. No; I don't think that anybody except Mr. Edison gave me any instructions or assistance or advice. Whether Mr. Edison had read anything or knew anything about Siemens, I don't know.

x-Q. 323. Do you know whether he had heard anything about Siemens at or before the time he gave you instructions about Exhibits 8, 9, 10 and 11?

A. No; I don't know.

x-Q. 324. Have you conversed with any other per-

son besides Mr. Edison concerning Siemens' electric 265
railway?

A. I think I have, but do not remember any particular conversation.

x-Q. 325. Give the names of the persons other than Mr. Edison, with whom you conversed concerning Siemens' electric railway?

A. I think I conversed with Mr. Hornig, but don't remember any other person particularly.

x-Q. 326. State as nearly as you can the conver-
sation which occurred between yourself and Mr. 266
Hornig?

A. I can't state the conversation at all.

x-Q. 327. Can you remember what you said to Mr. Hornig concerning Siemens' electric railway?

A. No; I can't.

x-Q. 328. Do you remember of any one besides Mr. Hornig speaking to you concerning the Siemens electric railway?

A. No; I do not remember any one.

x-Q. 329. Were you in the habit of meeting people 267
who came to Menlo Park to see the electric railway of Edison?

A. No; I wasn't in the habit; it happened often.

x-Q. 330. Do you know at this time why the Siemens electric railway would not answer Mr. Edison's purpose?

A. No; I do not.

x-Q. 331. Did you ever see a model or a drawing of the Siemens electric railway?

A. I think I have seen some illustrations of his 268
Paris electric railway.

x-Q. 332. Where did you see those illustrations?

A. I think it was in some illustrated paper that was sent to me.

x-Q. 333. Who sent it to you?

A. If anybody, it was Mr. Charles Batchelor.

x-Q. 334. Who is Mr. Batchelor?

A. The gentleman who has charge of Mr. Edison's exhibit in Paris.

x-Q. 335. Was the paper sent to you from Paris?

269 A. All the papers he sent me came from Paris.

x-Q. 336. Was the drawing contained in the paper sent to you by Mr. Batchelor, accompanied by a description?

A. I don't remember.

x-Q. 337. Was the paper printed in the French language?

A. All the papers he sent me were in the French language.

x-Q. 338. Is your knowledge of French sufficient
270 to enable you to read an article printed in the French language?

A. My knowledge is sufficient to enable me to understand an article generally.

x-Q. 339. What was the name of the paper sent you by Mr. Batchelor containing a description of the Siemens Railway?

A. I do not know that he did send it to me. I only stated that I think he did. I don't know the name of the paper.

271 x-Q. 340. Do you remember seeing any other illustration of the Siemens Electric Railway besides that contained in the newspaper sent you?

A. No; I do not remember to have seen any other.

x-Q. 341. You spoke of translating for Mr. Edison an article concerning the electric light, from a paper called "Der Techniker." Did that paper contain any allusion to Siemens' Electric Railway?

A. I don't think it did.

x-Q. 342. Do you remember to have heard that a
272 description of Siemens' Electric Railway was published in "Der Techniker" or any foreign newspaper?

A. I do not remember of any particular case.

x-Q. 343. When did you first hear of an electric railway?

A. I believe I heard of such experiments when I was a boy. Since then I think the first was Mr. Edison's own.

x-Q. 344. You say you think the first was Mr. Edison's. Can you swear positively that you never

heard of an electric railway before that of Mr. Edi- 273
son's?

A. No, I can't swear; but I don't remember hearing of any before.

x-Q. 345. When did you first become acquainted with Mr. Hornig, concerning whom you have testified?

A. I think it was in February, 1880.

x-Q. 346. How were you paid for your work for Mr. Edison at Menlo Park—in stock or money?

A. In money. 274

x-Q. 347. Are you now, or have you been, a holder of any stock issued by any company formed to work Mr. Edison's patents?

A. I am a holder of stock.

x-Q. 348. Please examine Edison's Exhibit No. 2 and state whether the words "Elec. tramway, J. K.," were written after the words "May 18th, 1879," and if yes, how long after?

Counsel for Edison objects to any question
touching the exhibits introduced during the 275
testimony of this witness, upon the ground that he has been already cross-examined at length in regard to each one of them, and gives notice that at the hearing he will move to strike out all further questions and answers upon cross-examination touching these exhibits.

A. I suppose they were written after, but can't
tell how long. They may have been written im- 276
mediately after with another pencil.

x-Q. 349. Can you explain why the words "May 18th, 1879," are written with a light touch or light pressure on the pencil, and the words "Elec. tramway, J. K." with what appears to me to be a heavy pressure?

Same objection to this as to previous question.

A. I suppose it was this way: first, I dated them

277 all, and afterward, before laying them away, I
marked them what they are, and signed them.

x-Q. 350. Can you explain why the final "y" in
the word "tramway" in Exhibits 1, 2, 3, 4 and 5,
is a straight heavy down stroke, while the final
letter "y" in the word "May" in Exhibits 1, 2, 3,
4 and 5, is a loop?

Same objection.

A. It is this difference which you mention in your
278 question which leads me to think that I dated them
all first and marked and signed them all afterward
in haste, which also explains to me the error I made
in one in marking it first "E. L.," and then erasing
it and marking it with other words instead.

x-Q. 351. How long after you dated them then
did you mark and sign them?

Same objection.

A. I cannot say exactly how long it was, but I
279 think it was the same day when I put them away
in the drawers.

x-Q. 352. What day was that?

Same objection.

A. The day of the date they bear.

x-Q. 353. How are you in the habit of writing
"y," by direct down stroke of the pen as shown in
the final letter of "tramway" in Exhibits 1, 2, 3,
4 and 5, or with a loop as shown in the final letter
of the word "May" in each of the Exhibits 1, 2, 3,
280 4 and 5.

Same objection.

A. In writing fast I generally make just the
down stroke.

x-Q. 354. I understand then that in writing the
word "tramway" you were writing fast?

Same objection.

A. I conclude the same way.

x-Q. 355. Have you any other reason to give why

the down stroke in the final letter of the word 281
"tramway" should be a straight line, and why
each "y" in the word "May" should be formed with
a loop?

Same objection.

A. I have this reason: that writing in English
was at that time comparatively new to me; that is,
I had not had much of it to do previously, and I
changed the shape of letters very often.

x-Q. 356. Please examine Exhibit No. 8, and state
whether any model or working machine was ever 282
constructed in accordance with that drawing.

A. There was no working machine made accord-
ing to this drawing; but as to whether a model was
made I am not quite sure.

x-Q. 357. Please examine Exhibit No. 10, and
state whether a model or working machine was
ever made from the drawing there illustrated.

A. There was no working machine made, but I
am not sure about the model.

x-Q. 358. Please examine Exhibit No. 11, and 283
state whether any working machine or model was
ever made from the drawing therein?

A. There was no working machine. I am not
sure whether a model was made or not.

x-Q. 359. When were the first drawings made,
from which a working machine was constructed?

A. I think in February or March, 1880.

x-Q. 360. Who made that drawing?

A. Mr. Hornig.

x-Q. 361. When did you first see a dynamo elec- 284
tric machine substantially similar to the one which
you have illustrated in Exhibits 8, 10 and 11?

A. About April, 1880.

x-Q. 362. Where did you see that dynamo electric
machine?

A. In Mr. Edison's machine shop at Menlo Park.

x-Q. 363. How was the armature of that machine
wound?

A. Substantially the same as they are now in the

285 same size of machines of Mr. Edison's construction.

x-Q. 364. Was that the first dynamo electric machine Mr. Edison ever constructed?

A. No, sir, we had built a great number before.

x-Q. 365. Do you understand the construction and operation of the dynamo electric machine which you have illustrated in Exhibits 8, 10 and 11?

A. Yes, I have a general knowledge of it.

x-Q. 366. What was the object of having the part of
286 the field magnet within which the armature revolved, of curvilinear form?

A. The object is to have the armature as near to the field of force as possible.

x-Q. 367. If dynamo electric machines were made by Mr. Edison before April, 1880, how was it that you did not see them?

A. I understand question 361 to refer to dynamo electric machines constructed and used as an electric locomotive.

287 x-Q. 368. Is the armature which revolves in the field of force as illustrated by you in Exhibit 8 entirely covered with insulated wire?

A. Yes.

x-Q. 369. No conductor of electricity is shown as connecting the commutator and other parts of the machine in Exhibit No. 8, is it?

A. It is not.

x-Q. 370. No method of insulating the flange of the wheel from the hub is shown in Exhibits 8, 10
288 and 11, is it?

A. No, there is none shown.

x-Q. 371. No method of insulating the axle from the tread or flange of the wheel is shown in Exhibits 8, 10 and 11, is there?

A. No, it isn't shown.

JOHN KRUESI.

THOMAS A. EDISON, a witness produced in his own 289
behalf, testifies on oath as follows, in answer to questions proposed to him by George W. Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and occupation?

A. Thomas A. Edison; age, 35; residence, Menlo Park, N. J.; occupation, inventor.

Q. 2. When did you first see or hear of any kind of an electric railway?

A. About twenty-seven years ago when I was a 290
small boy, I saw a circular electric railway at a lecture. The track was on a large table and was connected to a battery which supplied current to the rails. A small electric locomotive ran on these rails, and ran around the track with great velocity. This was in Milan, Ohio.

Q. 3. When did you first make or attempt to make any sort of an electric railway?

Counsel for Field calls attention to the fact
that the witness calls for his preliminary 291
statement, and examines the same before answering the question.

A. In the winter of 1872–73, I conceived the idea of carrying messages by means of an electro-motor running on telegraph wires which were to be the rails for the motor as well as the means for conducting electricity to the motor. I also tried practically running a small motor on two stretched wires in my laboratory, which was about January or February, 292
1873.

Latter part of answer objected to as inconsistent with witness's preliminary statement.

Q. 4. At that date what information, experience and knowledge did you have of what you would now regard as the essential elements of an electric railway. Please make your answer a little in detail?

A. I had run on a railway as a newsboy nearly every day for four years; had been a telegraph op-

293 erator and worked on various railways; and in 1872
and '73 I was familiar with electro-motors and magneto electric machines, and all that was essential to devise an electric railway.

Q. 5. What next turned your attention to the subject of electric railways, and when was it?

A. In July and August, 1878, I went out to San Francisco and returned, and in passing over the State of Iowa, I conceived the idea that if an electric railroad could be made to operate economically
294 it would be of great value for drawing grain to the
main lines of railroad and thus extend the radius of economical grain production; and when I had returned to Menlo Park in the latter end of August, 1878, I had studied out in my own mind a system of electric railroads.

Q. 6. How complete in detail had you studied out in your mind this system?

A. I had studied it out very completely but had not at that time decided as to which detail or varia-
295 tion of the many devices should be used.

Q. 7. Had you at that time studied out the details of the system so completely that you could have imparted to other persons, of proper mechanical skill, information from which they could have constructed an operative electrical railway?

> Question objected to as suggestive and leading by counsel for Field and for Siemens.

A. I have already testified that I had studied it
296 out fully.

Q. 8. Did you after your return from California impart to others what you had studied out in regard to electric railways, and if so, how soon after your return?

> Question objected to as leading by counsel for Siemens and for Field.

A. I imparted to others immediately on my return the idea of a system of electric railroads which I thought applicable to the purpose, which I have already testified to.

Q. 9. How full was the information you so im- 297
parted?

A. Sufficiently full to permit one skilled in the art to have made an electric railway.

Q. 10. What steps thereafter did you take, and when, to produce an electric railway such as you had conceived of and had explained to others?

> Objected to by counsel for Field as assuming that to have been done which has not been proven to have been done.
>
> Same objection by counsel for Siemens. 298

A. In February or March, 1879, I asked Mr. G. P. Lowrey, who was then one of the largest stockholders of the Edison Electric Light Company, if he could not get the company to put up the money to construct an electrical railway at Menlo Park, as I had then, in my experimenting with electric lighting, produced a very economical dynamo machine and electro motor. He replied that it would be no use,
and that I should give my whole time toward the 299
perfection of the electric light. I, however, continued to figure and make various calculations more relating to the economical part of the railway than to the technical part, and in May, 1879, I had working drawings made of an electric locomotive and track, as well as models of a trestle work upon which the electric railway was to be built. I continued experimenting on increasing the economy of transferring horse power into electricity by means of
dynamo machines, and re-converting the same back 300
into power by means of dynamo machines used as electro motors. I determined to construct the railway the first chance I could get the money to do so. In February, 1880, I had obtained money of my own amounting to about 15,000 dollars, and I immediately, in February, 1880, commenced the construction of an electric railway and appliances at Menlo Park. Such road was three-quarters of a mile long. The railroad and locomotive and appliances were completed in May, 1880, and was suc-

301 cessfully operated at that time, and has been operated successfully many times since, and I think as many as 5,000 people have ridden over it.

Counsel for Field calls attention to the fact that this answer was made after the witness had again consulted his preliminary statement and various account books.

Q. 11. I call your attention to the issues presented by the Patent Office in this interference, which read as
302 follows: "I. In an electric railway the combination of one or more stationary dynamo electric machines with conductors extending along the whole line and formed partly or wholly by the rails themselves, on which rails are vehicles having dynamo electric machines fixed thereon for imparting motion thereto, the electrical connection between said last-named dynamo electric machines and the stationary dynamo electric machine being maintained continuously by the wheels of the vehicle, with or
303 without the aid of contact rollers, springs or brushes.

"II. In an electric railway the combination of one or more stationary dynamo electric generators driven by suitable power, a conducting circuit formed wholly or in part of suitably insulated lines of rails; a wheeled vehicle adapted to move on said rails, and having one or more electro dynamic motors impelling the same, one pole of said motor being in electrical connection with a stationary gen-
304 erator through one line of conductors, and the other electrically connected with the other line of conductors, for completing the circuit through the stationary generator." When did you conceive the particular invention set forth in these issues?

Objected to by counsel for Siemens, and counsel for Field as leading.

A. In July, 1878.

Q. 12. When, if ever, did you impart to others your conception of these particular inventions in issue?

A. In August, 1878.

Q. 13. When, if ever, did you produce or cause to 305
be produced sketches of these particular inventions in issue?

A. I made some sketches in September, 1878.

Q. 14. Have you preserved them; if not what has become of them?

A. I have been unable to find them.

Q. 15. What are the earliest sketches which you have been able to find relating to the matter in controversy? 306

A. Exhibits Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11.

Q. 16. Please examine Exhibits 1 to 7 inclusive, and state, if you know, who made them, and when each was made?

A. The sketches were made by me. The dates and words "Electric tramway" were made by Mr. Kruesi.

Q. 17. Please examine the sketches 8 to 11 inclusive, state by whom they were made, if you know, 307
and when?

A. The sketches 8, 9, 10 and 11 were made by Mr. Kruesi, at the date marked on them, or within one day of that date. In Exhibit No. 9 the words "Electric tramway" are in my writing, and I am not sure as to whose sketch—whether mine or Kruesi's—it is, which is shown on the exhibit. The figures and writing, however, except in the instance I mentioned, are Mr. Kruesi's.

Q. 18. State, if you know, whether or not these 308
exhibits were made under the direction of any person, and if so, what person?

A. They were made under my direction by Mr. Kruesi.

Q. 19. Please examine sketches 1 to 7 inclusive and state what invention is illustrated in each of them?

A. No. 1 represents a motor driven by a dynamo machine, the motor being provided with a governor combined with circuit breaking devices of peculiar

309 construction, whereby the great spark due to the breaking of the electric circuit could be greatly reduced by breaking the circuit at a multiplicity of points simultaneously. This was to be used on the locomotive, and some time previous to the making of this sketch, this device, working on this principle, was made and tried and found to work satisfactorily. The levers of several sounders were used in place of the spring contacts, D, shown in the Exhibit No. 1. The words "reversible commutator" refer to reversing
310 the position of the brushes on the commutator, so as to permit the motor running in either direction. The word "governor" refers to a governor which was to be placed on the motor. The words "open the circuit lever" refer to a lever for opening the circuit entirely. In Exhibit No. 2, A is meant for an electric locomotive; B, a car drawn by the same; both A and B running on rails; C, a trestle work, upon which the rails are placed; D, a top view of the trestle work; and E, a portion of the
311 governor on the locomotive. No. 3 shows a sketch of trestle work with rails on top. Exhibit No. 4 shows a dynamo or magneto electric machines connected in multiple arc, and placed at the station and acting to supply electricity to the system. On the wires connected to the dynamo system on the left is a circuit reversing switch, whereby the direction of the flow of the current in a certain section of the track near the station may be changed. The system of dynamos on the right was connected to
312 another section of the track, and provided with a circuit reversing lever as implied by the words "same here." Exhibit No. 5 shows a dynamo or magneto electric machine at the top nearest the date, and an electric locomotive on a track underneath the first sketch. Exhibit No. 7 shows a communication between two stations of an electric railway by means of telephones, the circuit being made up of one side of the track and the earth. Exhibit No. 6 shows a station with a side-track for crossing trains, wind power being utilized to drive the dyna-

mo machines as an auxiliary power. Automatic 313
switches being arranged at both ends of the side track. Such switches being operated by magnetism produced by electricity sent over wires leading from the station, as shown on the right and left. On the right hand side on the track that passes nearest to the station, are shown an electric locomotive and two cars loaded with bags of wheat. The track furtherest from the station is the side track. The sketch immediately under the station represents a section of trestle work. The two 314
sketches on the right are telephones. The sketch was made by me. The figures underneath the trestle work sketch at the bottom of the exhibit, as well as the words "per mile," were made by me. The figures were some calculations as to the cost per mile of electric tramway.

Q. 20. Please explain Exhibit No. 9, and state if you remember the circumstances under which it was made.

A. Exhibit No. 9 shows some figures as to the 315
cost of electric railway. These figures were made by Mr. Kruesi, who had instructions to ascertain the cost and to arrange the materials to the best proportion to obtain reliability and initial economy of investment.

Q. 21. Please explain Exhibit No. 8, and tell what it is, and what it illustrates?

A. The exhibit represents an electric railway with an electric locomotive and a loaded car, drawn on a scale of one inch per foot. The sketch on the left 316
is an end view of a locomotive and trestle and track, and electrical conductor, F, F. The sketch on the right illustrates a side view of the locomotive and a loaded car as well as the trestle.

Q. 22. Please explain Exhibit No. 10; state how the same compares with the left-hand figure of Exhibit No. 8?

A. The sketch shown in Exhibit No. 10 is the same as the left-hand figure of Exhibit No. 8, except that it is drawn on a scale of two inches to the foot.

317 Q. 23. Please examine Exhibit No. 11, and explain the same fully and in detail, including the mode of operation?

A. The sketch is a front view of an electric locomotive, the governor being horizontal instead of perpendicular as in Exhibit No. 8, and the extra copper conductors being dispensed with and ordinary rails used, both for conveying the current and for traction. I notice in the sketch that some changes have been made which do not belong to the drawing
318 proper, such as the faint outlining of the upright governor shown in the left-hand figure of Exhibit No. 8, and also of the addition of devices for taking the current off from a copper conductor, and also an alteration on the left-hand side of the drawing, of the top of the rail. Whether the drawing was drawn over a light sketch and these devices just described not rubbed out, or whether they were made to explain the difference between one way and another of taking off the current to some
319 person, I cannot say. I believe that these extra marks were made when explaining the drawing to some person, whom I cannot now remember.

By consent the taking of further testimony was postponed to Tuesday, November 22, 1881, at same place and time.

Wm. H. Meadowcroft,
Notary Public,
New York Co.

320

Pursuant to adjournment the taking of testimony was continued on Tuesday, November 22, 1881, the same counsel being present.

Q. 24. At the date of that sketch or drawing of Exhibit No. 11, what provision, if any, had yon made for a continuous electric conducting rail, or for making the rail continuous?

A. I proposed to use copper strips beneath the fish plate connecting one rail with the other.

Q. 25. At the same date what means, if any, had you proposed for conducting the electric current 321
from the rails into the locomotive?

A. A paper wheel, in which the rim of the wheel was insulated from the hub on each axle.

Q. 26. At the same date what means, if any, had you proposed for reversing the direction of the locomotive?

A. I proposed two methods: one reversing the direction of the flow of the current through the bobbin, the other the reversing of the commutator brushes as indicated in Exhibit No. 1. 322

Q. 27. At the same date what means, if any had you devised for arresting or stopping the movement of the locomotive upon the track?

A. I had thought of several different electric brakes for stopping the train, but did not seriously contemplate their use at first, as hand brakes would be sufficient for my purposes at the time.

Q. 28. At the date mentioned what means, if any, had you devised for insulating the rails them- 323
selves?

A. I had conceived the idea of insulating the spikes from the rail, and also japanning the whole of the rail except the top; also immersing the ends of the ties in an insulating substance.

Q. 29. At the same date how far had you progressed in the production of commercially economic dynamo-electric machines?

A. I had made an enormous number of experiments from 1878 up to the date mentioned on the 324
production of an economical dynamo machine and electro motor, and at that date had reached the highest economy, I think, in this connection, ever obtained up to that date.

Q. 30. What, if anything, was done by you at about that date in the making of models or working parts connected with your system of electric railways.

A. I had made the models, Exhibits 12, 13, and 14.

Q. 31. Do you remember anything else?

325 A. I was making and conducting experiments on electric motors and dynamo machines.

Q. 32. I wish you would look at the papers which are pasted on each of the Exhibits 12, 13, and 14, and state if you recognize the handwriting and signatures upon the same, and if so whose handwriting and whose signatures?

A. Yes, sir; the writing is that of Charles Bachelor; it is witnessed by himself and John Kruesi.

Q. 33. What relation towards you did Mr. Bache-
326 lor have at that date, and where is he now?

A. Mr. Bachelor was my principal assistant; he is now at the Paris Exposition of Electricity.

Q. 34. What reason, if any, did you have at that date for not immediately carrying your plan into operation in the construction of a working electrical railway?

A. I hadn't the money to conduct such an expensive experiment.

Q. 35. When did you first hear that Mr. S. D.
327 Field had made any invention in electric railways?

A. It was a patent issued to him some time in 1880. I will furnish the date afterward.

Q. 36. When did you first hear that Mr. Ernst Werner Siemens had produced or was producing an electric railway?

A. I think about August, 1880, but I may be mistaken. I will hunt the matter up further.

> Counsel for Field and for Siemens call at-
> 328 tention to the fact that the witness answers this and the previous question only after a lengthy examination of scrap books.

Q. 37. When did you first hear that Mr. Siemens was giving attention to the subject of electric railways?

A. I think about the time that I was building my road.

Q. 38. At about what date, as near as you can remember, did you begin preparations for filing an application for a patent for your electric railway?

A. In March or April, 1880; it might have been 329
as early as February, 1880. I have so many patents that it's difficult for me to state when their preparation was commenced. Mr. Wilber, who prepared the case, could doubtless give the exact date.

> Counsel for Siemens and Field request that whenever the witness refreshes his memory or fixes his dates by written memoranda, scrap books or any paper whatever, the fact of his so-doing shall be noted on the record.

Q. 39. Do you remember whether you had models 330
made for the Patent Office to accompany the pending application; if so, when were they made?

A. I don't remember.

Q. 40. Please examine copy of your pending application in this interference, together with the drawings attached thereto, and state what features if any illustrated in those drawings you find illustrated in the sketches marked Exhibits 1 to 11 in-
clusive; please answer in detail? 331

> Counsel for Siemens and for Field object to the question because the drawings themselves should show what is sought to be elicited by the question without any explanations by the witness.

A. The automatic switch for crossing trains is illustrated in Exhibit No. 6 and in figure 1 of the application; in figure 1 S L is the switch rod at both sides of the station; the dotted lines 5 and 6 are the
circuits. The track M T in figure 1 of the applica- 332
tion, as well as M T′ and M T″ is represented in Exhibit 4. Figure 5 of the application is represented by D in Exhibit No. 1 being the governor. Figure 3 in the application is represented by the figure in Exhibit No. 11, except the dynamo bobbin in the exhibit is not connected direct to the driving wheels in the application. The track upon which the locomotive runs in figure 3 is the same as that in Exhibit 11. One of the functions of the lever shown in figure 5 is the same as that shown in Ex-

333 hibit No. 1, marked C. The dynamo B in figure 1 of the application is represented by the dynamo B in Exhibit No. 1. The side track Sw. in figure 1 of the application is represented in Exhibit No. 6, being the track furtherest from the front of the station.

Q. 41. State whether or not you find in the drawings of the application, as well as in the exhibits mentioned, a central station from which electricity is conducted to the rails of a railway?

334

Same objection as to previous question by both counsel.

A. Yes, sir.

Q. 42. Please examine the application of S. D. Field in this interference, together with the drawings attached thereto, a certified copy of which is now handed you, and compare the same with the inventions illustrated in your Exhibits 1 to 11 inclusive, and state wherein or in what respect, if any,
335 said invention of Field shows an advance over the invention illustrated in your said exhibits, and in what respect, if any, your said exhibits show an advance over said inventions of said Field, as illustrated in the drawings of his said application?

Question objected to by counsel for Siemens and for Field as incompetent.

A. In Exhibit No. 4 are shown sections of a track fed with current by dynamo machines, while in
336 Figure 5 of Field's application a dynamo machine supplies current to an insulated strap and to a box and one rail connected to the earth. The method of connecting the sections of the track I do not find in these diagrams, neither do I find where he connected the two poles of the stationary dynamo with the two rails forming the track. His method of taking off the current by means of a strap insulated from the traction rails is similar to that shown in my Exhibit No. 10, except that my straps or conductors were arranged to obtain better insu-

lation. Both myself and Mr. Field show a mobile 337
electro motor running on a track as in my Exhibits Nos. 8, 10, 11, 6, 5 and 2, and in Field's application, Figures 2, 3 and 5. The direction of the current through the dynamo is changed by reversing the commutator brushes by Mr. Field. This method is also indicated in my Exhibit No. 1. The circuit to the motor is broken by disconnecting the contact lever from the strip on the road-bed by Mr. Field. In my case the circuit is opened on the motor itself in the ordinary manner, as indicated on Exhibit 338
No. 1. In my Exhibit No. 11 the track itself was to be used both for conveying the current and for traction, and the wheels were to have their rims insulated from the hubs. In Mr. Field's application no provision seems to be made or intimation that the track is to be used both for conducting the electricity to the motor and for traction purposes. No attempt at insulating the traction rails is apparent. In my opinion the method shown in Mr. Field's application for conveying the current to the motor 339
would work very unsatisfactorily in practice, both as to reliability and economy. I do not see that Mr. Field shows in his application any advance over the methods and the system indicated in my Exhibits 1 to 11; on the contrary, I consider them far less practicable.

The objection to the question is renewed as to the answer, and notice of motion is given to strike the same out as utterly incompetent, and in view of the relations of the wit- 340
ness to the subject matter of his testimony as absurd.

Q. 43. Do you find any provision in Mr. Field's said application for one train passing another, and in that respect does it differ from the inventions illustrated in your exhibits?

Counsel for Siemens and Field object to this question as immaterial, incompetent and having no relation to the subject matter.

341 A. I do not find any means indicated in Mr. Field's application for crossing trains, and it differs in that respect from my exhibits.

Q. 44. Question 42 is repeated as applied to the invention of Mr. Siemens, as shown and illustrated in his pending application in this interference, a certified copy of which is now handed you.

> Objected to by counsel for Siemens, because Mr. Edison is an interested party to this interference, and the answer sought to be
> 342 elicited would obviously be in the nature of an argument coming from an interested party, or a scientific opinion from an expert who is interested in the decision of this interference.

A. I have made the comparison and find that generally, everything shown in Mr. Siemens' application is indicated in my Exhibits 1 to 11, but I do not find any means for stopping the train elec-
343 trically; neither do I find any means for reversing the direction of the train, electrically; neither do I find means for governing the speed of the train; neither do I find means for permitting the crossing of trains; Neither do I find ordinary railroad axles with their wheels insulated from the axle, in Mr. Siemens' application, while intended and indicated in my Exhibits 1 to 11.

I also find in Mr. Siemens' application methods of carrying the current to the mobile motor by con-
344 ductors other than the rails, substantially as indicated in my Exhibits 1 to 11; and I do not find that the system described by Mr. Siemens is as far advanced as that indicated in my Exhibits 1 to 11, basing this affirmation upon the results of later experiments.

> Answer objected to by counsel for Siemens, in addition to the objections last entered, that the answer of Mr. Edison is irrelevant, as it relates to matters not involved in this interference, but to matters involved in Mr. Edison's application, which the office has not put in interference. 345

I wish to make a further answer to this question, relative to the comparison between my Exhibits 1 to 11 and the application of Siemens, which is that in both cases trestle work is shown.

> Same objection, and the latter part of the answer is further objected to because no trestle work is shown, or described or claimed in the application of Edison involved in this interference, and therefore the testimony in 346
> relation thereto by Mr. Edison is immaterial.

Q. 45. When did you set about building your electric railway at Menlo Park, and why did you not build it at an earlier date?

A. I commenced it in February, 1880, and finished it in May, 1880. Owing to the large amount of money required to properly build and test an electric railway, I did not succeed in obtaining money until February, 1880, to build the road. Had I the money 347
I would have built it in 1878.

> The last sentence of this answer objected to by counsel for Siemens, as irresponsive to the question.

Q. 46. Give as nearly as possible the dates of construction and equipment of your railway, at different stages of progress toward completion.

A. I find by referring to my memoranda, that Mr. Hornig directed the rails to be ordered April 2, 348
1880; that men commenced to work on the roadbed April 10, 1880; commenced laying the rails April 11, 1880; magnets of the locomotive and magnetic power tested April 28, 1880; electrical connection made between the station and the rails of the track May 11, 1880; electric locomotive tested in the shop, May 12, 1880; locomotive run on the track May 13, 1880.

Q. 47. Please describe in detail that railroad, with its equipments and stationary power.

349 A. The railroad consisted of a track about three-quarters of a mile long, with grades in places 162 feet to the mile, and curves of 30 feet radius. The track consisted of two T rails, the same as used on ordinary railroads except they were lighter, being 16 pounds to the yard, and the gauge was 3 feet 5 or 6. The rails were spiked to wooden ties in the ordinary manner. Two conductors, one from each rail forming the track, were led into the engine room, about 40 feet distant from
350 the end of the track, the ends of which were connected to two dynamo machines kept continuously running while the railroad was being operated. A steam engine was used to rotate the dynamo machines and furnish power. The ties were placed up from the earth, or, in other words, the road was not fully ballasted, so that the earth die not come up to the top of the tie, and thus increase the leakage of the current to the earth. The rails were connected electrically and mechanically
351 together, by means of the ordinary fish-plates and bolts, with the addition of copper strips from the end of one rail to the other, between the fish-plates and rails; the copper strips being used to diminish the total resistance of the track as an electrical circuit, so as to insure economy in the operation of the locomotive.

The locomotive, when first put on the track, consisted of two axles, with wheels, the rim of each wheel being insulated from the hub by means of
352 wood. The two rims of the main driving wheels were connected, by means of metallic spider-form arms, to a small cylinder of brass, upon which brushes rested, the two brushes being connected to the motor. The current from one rail, passing up through the insulated rim of one wheel, passed down, through the tree arms forming the spider, to the brass cylinder; thence, by a brush, to the field magnet and to reversing and circuit-opening mechanism, through the field magnet and circuit-reversing mechanism and induction bobbin, to the other

brush; thence, through the spider, to the rim of the other wheel, down to the rail: thence to the station, 353
through the dynamos, and back to the other rail. A governor was included in the circuit of the induction bobbin. The locomotive was started by closing the circuit, and the direction which the locomotive passed over the track was controlled by reversing the direction of the flow of the current through the induction bobbin, while the field magnet had a constant current flowing through it, which it had at all
times when the tracks were connected to the dy- 354
namos at the station, and whether the induction bobbin circuit was open or not. When the locomotive was first designed, it was determined to use steel bands; afterwards it was determined to try friction wheels, for connecting the rotating bobbin with the driving wheels of the locomotive, and friction wheels were used the first day we ran the locomotive. The friction wheel broke. We then took the wheels off, and put on pulleys, connecting the
driving shaft and the bobbin by leather belts. A 355
pulley on the bobbin shaft of the dynamo machine was connected, by means of a belt, to a large pulley on an intermediate shaft. On this intermediate shaft was another smaller pulley, on which was a leather belt, running over it and also over a pulley on the axle of the main driving wheels. The friction device was an attempt to obviate the great loss of power when transmitted through a belt system, as in electric railroad locomotives the high rotating
speed of the bobbin must, in practice, be con- 356
nected to the driving mechanism by means of some intermediate mechanism for reducing speed of actual rotation, where any considerable power from such a locomotive is required. The locomotive was also provided with a head light, consisting of a reflector, in front of which was an incandescent electric lamp, lighted by electricity derived from connecting the terminals of the electric lamp to the two brushes resting on the spider-connected contact cylinder. Hand brakes were used. At first a sin-

357 gle car, the same as shown in the photograph which I here present, was used, the car being the second one from the locomotive.

Q. 48. Is the photograph to which you have called attention a correct representation of the track and of the locomotive at the time when belt gear was substituted for friction gear?

A. Yes, sir; except that the electric lamp has been taken off.

358 Photograph referred to put in evidence and marked "Edison Exhibit No. 15."

Q. 49. How many cars and of what description were used with the locomotive at the beginning?

A. One car was used at first, being the middle car shown in the photograph. It was built on a truck provided with two axles and four wheels, the rims of the wheels being insulated from the axles by means of wood.

359 Q. 50. How many cars were afterwards added, and of what description and when?

A. The second car was the same as the first car, except that it had no awning or seats for passengers, but was intended only for freight; I can't remember when this car was put on the track, but it was I should say, a month after the railway was first operated. The third car was a closed passenger car, being the last car shown in the photograph Exhibit 15. The trucks, electrically considered, were
360 the same as those on the first car. This car I think was put on the track July, 1880. Under the bottom of the car was an electric brake operated by current derived from the track. This brake was operated one or two days when the car was drawn by the electric locomotive.

Counsel for Field calls attention to the fact that the above answer was given after the witness had consulted memoranda.

Q. 51. How long was this first friction gear used

upon the locomotive, and how soon thereafter was 361
the belt pulley gear substituted?

A. The friction gearing was worked but one day. Belts were substituted I think two days afterwards, the machine being originally designed to admit of the change, in case the friction gearing did not work satisfactorily.

Q. 52. How much power were the stationary dynamo machines capable of producing?

A. The dynamo machine at the station was capa-
ble of transferring twenty horse power, and the 362
motor of the locomotive capable of exerting twenty horse power with one machine at the station, and about thirty to thirty-five horse power when two machines were used at the station. A speed of 42 miles per hour, with 31 persons on the car, was obtained, notwithstanding the heavy grades.

Q. 53. Is that locomotive in the same condition, as to construction and arrangement of parts, that it was when the belt gearing was put upon it?

A. I think it is in nearly the same condition. 363
There may be some extra holes drilled in the frame by reason of the substitution of worm and worm wheel mechanism for the belts. This worm and worm wheel mechanism was afterwards taken off and the belts put back.

Q. 54. What was the reason for substituting the worm wheel gear?

A. We desired to run the bobbin of the dynamo at full velocity, while the locomotive itself should
run with extreme slowness, so that the mechanical 364
power can be multiplied and permit of the hauling of heavy trains up inclines.

Q. 55. How long was this worm wheel gear used and what became of it?

A. I think it was only used a few days, and the parts, I believe, are at Menlo Park.

Q. 56. What change, if any, was required in the locomotive proper to substitute this worm gear for the belt driving mechanism or *vice versa*?

A. A change of intervening mechanism, brought

365 about by changing the character of the driving
device on the shaft of the rotating bobbin.

Q. 57. How much time would be required to make
such a change?

A. Several days.

Q. 58. I mean where the parts are already constructed.

A. Several hours.

Q. 59. What was the character and extent of use
to which this railroad was applied?

366 A. It was run all during the summer of 1880,
nearly every day, carrying passengers back and forward.

Q. 60. How complete a demonstration, in your
judgment, of this railroad did you make to determine its commercial capacity?

A. We made a complete demonstration. My experiments in 1879 proved to myself the economy of
converting the power of a stationary engine into
electricity, and causing such electricity to reproduce
367 mass motion through the intermediary of an electro
motor. The building of the railroad had for its object the exhibition to the public of a practical electric railway for the purpose of obtaining capital to
construct longer lines, and also to determine the
loss of current by leakage through the earth from
rail to rail, under various conditions of the weather,
and also to determine the constancy of the resistance
of the track circuit as a conductor under action of
traffic and weather. The economy, as far as motive
368 power is concerned, was known to me before the
railroad was built, from my experiments on dynamo
machines and motors. The object for which the
road was built has been attained.

Q. 61. In your judgment, could an electric railroad, in all respects like that made by you in May,
1880, be used now in commercial competition with
steam railroads?

A. Yes, sir.

Q. 62. I ask the same question with regard to the
electric railway illustrated in your Exhibits 1 to 11,
inclusive.

Counsel for Siemens objects to this question 369
because Exhibits 1 to 11 contain many devices
not involved in this interference. If the object of the question is to show the utility of
devices and their value, devices involved in
the interference should be specified.

Same objection by counsel for Field.

A. The electrical railway shown in Exhibit 15 is
only carrying out what is shown in my exhibits 1 to
11, and I answer, yes.

Q. 63. Have you at a later date commenced the 370
building of another electric railway; if so, state of
what length and the proposed power of the locomotive?

A. I commenced to build at Menlo Park another
electric railway, arranged and operated precisely as
the one shown in Exhibit 15. Such road is to be 2½
miles long; to be provided with a high speed passenger locomotive of 30 horse power, and a low
speed freight locomotive of 30 horse power. The 371
freight locomotive designed to haul eight small cars
at eight miles an hour, while the passenger locomotive is to haul two cars and run 60 miles an hour.
The work is now going on, the road bed being nearly finished, the locomotive and cars building. The
object of this road is to fully convince certain capitalists that a line of railway fifty miles long can be
operated by stations five miles apart or more, and
that a ton of freight can be hauled as cheaply per
mile as on a steam road operated at the place, and 372
under the conditions when the long road is to be
built.

Q. 64. Mr. Edison, will you procure and file as exhibits as soon as possible photographs of the locomotive run by you in May, 1880.

A. I will.

CROSS-EXAMINATION BY F. W. WHITRIDGE, ESQ., OF COUNSEL FOR FIELD.

x-Q. 65. Do you remember the name of the lec-

373 turer who described the electric railroad 27 years ago of which you testified?

A. No, sir.

x-Q. 66. Did you ever hear him but once?

A. No, sir.

x-Q. 67. What did he state the object of the railroad to be, do you remember?

A. No, sir.

x-Q. 68. Describe the locomotive a little more accurately and definitely which ran around upon the
374 track?

A. I only know that it was a locomotive. I was not near enough to see any of the details, except the track, the little engine, and the batteries.

x-Q. 69. Was there a car or any sort of a carrying vehicle attached to the locomotive?

A. No, sir.

x-Q. 70. Am I correct in understanding therefore that this electric railway of which you speak gave you the impression of being designed for no purpose
375 whatever?

A. I was a very small boy and didn't understand anything but the fact that I saw what I have stated.

x-Q. 71. Did you at any time subsequently hear of this lecturer and his railway?

A. No, sir.

x-Q. 72. Do you remember when your mind first recurred to this lecture after you had ceased to be a very small boy?

376 A. It has occurred to me at various times since that.

x-Q. 73. In what connection?

A. With electricity.

x-Q. 73. Applied, or in the abstract?

A. Applied.

x-Q. 74. How?

A. I thought it might interfere with an application for a patent.

x-Q. 75. What application?

A. For a patent on electric railroads.

x-Q. 76. One of your own?

A. One that I proposed to make application for. 377

x-Q. 77. When was this?

A. When was what?

x-Q. 78. When was it that you thought that this railroad might interfere with one of the applications which you proposed to make?

A. In 1878.

x-Q. 79. Did you take any steps to ascertain whether your idea that it might so interfere was correct or not?

A. No sir. 378

x-Q. 80. Was the application you referred to as one you proposed to make in 1878, and which you thought might interfere with this railroad of which you have testified, the application for the patent in controversy?

A. In 1878 I thought of making an application for a patent, and thought of this lecture at the time that I was thinking it over in my mind. Many of the devices which I thought of in 1878 and the general plan are shown in my application in interference. 379

x-Q. 81. Had you thought of this railroad at any other time before you thought of making this application?

A. I had thought the railroad out before I thought of making the application, and when I thought of making the application I thought of this railroad that I had seen many years before, wondering whether a public exhibition of a toy railroad on a 380 table could be used as a reference against an application for a patent on a electric railway on a large scale.

x Q. 82. Did you make any endeavor to find out whether this was the case or not?

A. No, sir.

x-Q. 83. Had you thought of this railroad which you had seen many years before at any other time before you began to think of making your application in this case, and if so in what connection?

381 A. Which application?

x-Q. 84. The application of 1878.

A. Yes, sir; I had thought of it in connection with the little motor which was to be run on wires in the winter of 1872-73.

x-Q. 85. In what way did you think of it then?

A. I thought of it for the reason I was trying to do the same thing for a purpose and in a slightly different manner, the object of the wire railroad being to connect the different branch offices of the
382 Western Union Telegraph Company to the central office, so as to send out and receive messages without the necessity of telegraphing them to and from the branch offices.

x-Q. 86. What do you mean by "the same thing for a purpose?"

A. I have already stated the purpose and the manner was different insomuch as my track consisted of telegraph wires which were to be suspended on poles and operated between two terminals.

383 x-Q. 87. Do you mean that you thought this early toy might answer for the purpose which you had in mind in 1872 and '73, for your electric motor on wires?

A. No, sir.

x-Q. 88. In what part of the winter of 1872 and '73 did this device occur to you, as near as you can remember?

A. My experiments revived the recollections of the old lecture, but I cannot state what time it oc-
384 curred to me, but it nevertheless occurred to me in the winter of '72-'73.

x-Q. 89. In what part of the winter of 1872-'73 did the idea of connecting main and branch telegraph offices by means of this electric motor running on wires, occur to you?

A. My impression is it was in December, 1872, and my further impression is that there was a sleet storm that winter that made me give up the idea.

x-Q. 90. Your memory of the early lecture was not, I understand you, revived until you began to

experiment with this means of connecting the main 385
and branch offices?

A. No, sir; although it might have been at different times in connection with my experiments in electricity, but I do not recall it.

x-Q. 91. Do you remember any more definitely when you left for the west in the summer of 1878?

A. I think I left about July 16th, 1878; I was at Rawlings, Wyoming Territory, on the eclipse expedition in July; I think the eclipse occurred on July
29th, 1878; we were there several days before it oc- 386
curred.

By consent, the taking of further testimony was postponed to Wednesday, November 23d, 1881, at 10 A. M., at same place.

WM. H. MEADOWCROFT,
Notary Public,
N. Y. Co.

387

Pursuant to adjournment the taking of testimony was resumed on Wednesday, November 23, 1881, at 10 A. M.; same counsel being present.

Counsel for Field desires to state that any portion of the cross-examination relating to portions of the direct examination, which were duly objected to, is made without waiver of said objections.

x-Q. 92. Do you remember when you returned 388
from your journey out west, in 1878?

A. The latter end of August, 1878.

x-Q. 93. How soon after your return did you impart to others your idea of a system of electric railway conceived during your journey?

A. I should say about within ten days after my return.

x-Q. 94. Do you remember when you first imparted it?

A. Within ten days after I returned.

889 x-Q. 95. I mean more definitely; the particular day or time of day?

A. It would be a very difficult matter for me after a lapse of nearly three years, to remember the exact day on which I imparted my ideas to others, and I cannot remember nearer than ten days.

x-Q. 96. How do you fix the time as being within ten days?

A. I fix the time by reason that having finished up my telephone and phonograph I was looking out
890 for something else to go into immediately on my return; and electric lighting and electric railroads were the schemes decided upon as the ones to take up; and I discussed them with others.

x-Q. 97. When did you begin work upon electric lighting, as nearly as you can remember?

A. If you refer to my commencing working after my return from the West, I commenced the early part of September, 1878.

x-Q. 98. I do not refer to that; I ask you when
891 you began work upon electric lighting; I mean was it before or after you went out West, in 1878?

A. I worked on electric lighting before and after I returned from the West.

x-Q. 99. Did you finish up the telephone and phonograph before you went out West?

A. I had finished them up so as to make them commercial—especially the telephone.

x-Q. 100. Did you begin to look out for something else to go into, only after your return, or were you
892 on the lookout as soon as you had finished with the telephone and phonograph?

A. I had many things turning over in my mind to go into before I had finished on the telephone and phonograph, but after my return I decided to go into electric railroads and electric light, as both could be worked in conjunction. The experiments in electric lighting on the production of efficient dynamos, which were convertible into motors, would advance the railroad at the same time.

x-Q. 101. Do you remember the time of your con-

versation with Mr. G. P. Lowrey, in 1879, to which you have referred? 893

A. As near as I can remember, it was in February or March, 1879.

x-Q. 102. What was the result of your calculations as to the economical part of the railway in 1878 and '79, to which you have referred?

A. I calculated that an electric railway could be erected and operated in the flat lands of Iowa, and other wheat-growing States of the Northwest, more cheaply than a steam railroad—first, by reason of 894
the small initial investment required and of the small operating expenses—the road being so conducted and operated as to be abundantly able to do all the traffic of the region through which it ran; which traffic would be quite insufficient to warrant the construction of a steam railroad made in the manner now in vogue; and I had calculated the cost to a point where I believed that such an electric railroad as I had thought out would be more economical than a steam railroad. In the far North- 895
west immense bodies of arable land, suitable for grain-growing, are beyond the area of economical production, and these lands are only brought within that area by railroad communication; but in most cases the traffic for years to come would not warrant the construction of a steam railroad; and I reasoned that if an electric railroad could be constructed at one-third the cost of a steam railroad vast tracks of arable land could be brought
within the limits of economical production and at 896
the same time pay handsome profits on the small investment required for an electrical railroad. And in my Exhibit No. 6, a windmill is shown at a station, my idea being that I could take advantage of the constant winds which prevail over these regions to obtain motive power which could by means of dynamo machines be turned into electricity, sent out on the railroad track to operate the electric locomotives and thus obtain the motive power cheaply, by taking advantage of the natural winds which prevail almost continuously in these regions.

397 x-Q. 103. The calculations to which I refer in my last question are those spoken of by you in the cost of your railway at Menlo Park. What was the result of those calculations?

A. That I could build an operative electric railroad cheaper than a steam railroad.

x-Q. 104. When you imparted your idea to others in September, 1878, do you remember how long it took you to do it?

A. I didn't time myself.

398 x-Q. 105. Question repeated.

A. As I didn't time myself, I don't remember.

x-Q. 106. Did you impart the whole of it at one time?

A. I imparted the general idea with sufficient details for the persons to whom I imparted it to have constructed an electric railway.

x-Q. 107. Do you remember how much you calculated your railroad at Menlo Park would cost?

A. I calculated that it would cost about from
399 3,100 to 3,600 dollars per mile.

x-Q. 108. Does that include the cost of the motor, cars, &c.?

A. No, sir.

x-Q. 109. How much did the railroad which you finally built at Menlo Park cost?

A. The road bed cost, if I remember right, about 2,500 dollars.

x-Q. 110. Was that cheaper than if it had been laid upon such trestles as are shown in your Exhibits
400 Nos. 12, 13 and 14?

A. Yes, sir; I believe it is; but I had about 400 feet of trestle in the road.

x-Q. 111. Is the cost of that included in the 2,500 dollars?

A. Yes, sir.

x-Q. 112. The 2,500 dollars, I understand you, covers the entire cost of the rails, and laying thereof so that they were insulated and formed a continuous conductor?

A. 2,500 dollars covered the cost of preparing the

road bed, laying the ties, laying down the rails ready for the passage of an electric locomotive. The 401
road was about three-quarters of a mile long.

x-Q. 113. Do you know exactly how long it was?

A. No, sir.

x-Q. 114. What was the cost of the electric locomotive?

A. I can't remember.

x-Q. 115. State it as nearly as you can approximately.

A. As it stands to-day I should say that 6,000 dollars would not pay for all the work and changes in 402
the original construction of the locomotive.

x-Q. 116. At what should you estimate the first cost of this locomotive?

A. I should say two thousand to two thousand five hundred dollars.

x-Q. 117. Was it built at Menlo Park, in your own workshops?

A. Yes, sir; most of it.

x-Q. 118. What was the cost, as near as you can estimate it, of the dynamo-electric machine which 403
was used at the station?

A. About nine hundred dollars.

x-Q. 119. Was this also built in your workshops at Menlo Park?

A. Yes, sir.

x-Q. 120. Were the electric-locomotive and dynamo-electric machine, at the station, both built expressly for this railroad?

A. The one on the locomotive was built ex- 404
pressly, but the one at the station was built for the electric light.

x-Q. 121. Do you remember whether the one at the station had been used before it was used in connection with the railway?

A. Yes, sir; it had.

x-Q. 122. Was the electric locomotive entirely new, in all its parts, or was some of the material which you had on hand in your workshops used in its construction?

405 A. There might have been some small parts, such as pulleys, that I had on hand, but mainly the locomotive was new.

x-Q. 123. How much less, as nearly as you can judge, did it cost you to build this locomotive than it would have cost to have built it had you not had the facilities which you had at hand at Menlo Park?

A. As I had complete working drawings, I could doubtless have had it built for far less money in New York than at my own shop.

406 x-Q. 124. Did you ever have any estimates made upon the cost of building this locomotive in New York?

A. No, sir; but I have since started a shop in New York, and had work done outside of my shops in New York; and, from the experience I have had, I am quite confident that I could have had the locomotive built for less money in New York than it cost me in my own laboratory.

x-Q. 125. About how many men did you employ

407 in your workshops, at Menlo Park, at the time this locomotive was built?

A. I think I had ten or twelve machinists in the shop.

x-Q. 126. Were the cars used upon the electric railway also built in your shops at Menlo Park?

A. All but the axles, wheels and boxes were built in my shops at Menlo Park.

x-Q. 127. About how much did the cars cost?

A. I don't remember.

408 x-Q. 128. Give it as near as you can, approximately?

A. I should say the three cars cost from $500 to $800 dollars.

x-Q. 129. Please look at Exhibits 1 to 7 inclusive, and state if you can remember definitely when you made them?

A. They were made about May 18th, 1879; I should say about one or two days previous to that time.

x-Q. 130. Do you remember on what day they were made?

A. I do not remember the exact day, but they 409
were made previous to May 18th, 1879. I think one day previous. They were a lot of rough sketches given to Mr. Kruesi to enable him to make the working drawings.

x-Q. 131. Did you accompany them with descriptions when you gave them to Mr. Kruesi, or did he make the working drawings from the sketches alone?

A. I explained them orally, making sketches to illustrate my explanations.

x-Q. 132. Have you any definite recollection of 410
the time when you did this, or do you fix it by means of the dates upon the sketches?

A. I fix it by means of dates on the sketches and by means of the dates on the trestle work exhibits, as I distinctly remember these trestle work exhibits.

x-Q. 133. You have no independent recollection of the particular time when you made those sketches?

A. I remember the putting of the paper with the 411
dates on the trestle work exhibits. From this I am enabled to set the dates on the Exhibits 1 to 7. I am also enabled from my general work to set the date, which is that marked on the exhibits.

x-Q. 134. Do you remember whether or not you made all of those sketches except No. 6 on the same day?

A. Yes, sir; I feel pretty sure that I made all of those on the same day except No. 6.

x-Q. 135. Do you remember whether or not you 412
made them in Mr. Kruesi's presence?

A. I think I did.

x-Q. 136. Do you remember seeing him write upon them?

A. No, sir; but I remember seeing the dates upon the exhibits within two or three days after the dates upon them.

x-Q. 137. Do you remember making Exhibit No. 6?

A. Yes, sir.

413 x-Q. 138. And when?

A. Within a day or two after Exhibits 1 to 7, exclusive of 6.

x-Q. 139. Do you remember when you gave Mr. Kruesi certain instructions about the cost and arrangement of material for the railroad?

A. About the time these sketches were made.

x-Q. 140. Do you remember what those instructions were?

A. I cannot remember all of them, but generally
414 it was to devise a trestle work which would have the maximum efficiency and economy, and also instructions as to the designing of the locomotive as indicated in the exhibits, said exhibits being used by me to assist these explanations.

x-Q. 141. Do you mean by "said exhibits," 1 to 7?

A. Yes, sir; 1 to 7.

x-Q. 142. Did you see Mr. Kruesi while he was making Exhibits 8, 10 and 11?

415 A. Yes, sir.

x-Q. 143. Do you remember how long it took him to make them?

A. No, sir; they were done very quickly.

x-Q. 144. Do you remember when you first thought of making the rails a continuous conductor by using copper strips beneath the fish plates?

A. Yes; I think it was in 1869.

x-Q. 145. Do you remember when the Edison Electric Light Company was organized?

416 A. In the fall of 1878.

x-Q. 146. Had you at that time your workshop established at Menlo Park which you have referred to?

A. I had a workshop at Menlo Park at that time.

x-Q. 147. About how many workmen did you employ in them?

A. I think I had about four or five machinists and several other people employed by me.

x-Q. 148. Were you a stockholder in the Edison Electric Light Company? 417

A. I was a stockholder on its organization and am now.

x-Q. 149. To what extent?

A. To a considerable extent.

x-Q. 150. Have you received any dividends on your stock up to 1880?

A. No, sir.

x-Q. 151. Do you know what the value of that stock was, between the time of the organization of 418
the company and 1880?

A. I don't know.

x-Q. 152. Did you ever hear of any of the shares of this stock being sold by any person prior to 1880?

A. Yes, sir.

x-Q. 153. Did you hear what the price was for which it was sold?

A. I heard it rumored that it sold as high 2,500
dollars a share. 419

x-Q. 154. What is the capital stock of the company and into how many shares is it divided?

A. The capital stock is $480,000; divided into 4,800 shares.

x-Q. 155. How many of those shares did you hold upon the organization of the company?

A. I refuse to answer.

x-Q. 156. If the company has 4,800 shares, what number of shares would you consider a considerable
number? 420

A. 500 shares would be a considerable number.

x-Q. 157. Did you have more than 500 shares yourself at the organization of the company?

A. I refuse to answer.

x-Q. 158. Did you have more than 600 shares at the organization of the company?

A. I refuse to answer as to the number of shares I had.

x-Q. 159. Will you give me any approximate idea of the number of shares you had—within fifty or a hundred or so.

421 A. I had a considerable number of shares, and with the exception of twenty, which I sold in 1881, I have all of them still.

x-Q. 160. Question repeated.

A. I refuse to answer as to the number of shares I had.

x-Q. 161. I don't ask you that; I ask you whether you will or will not give me any approximate idea of the number of shares you had; say for instance be-
422 tween a certain number of hundred?

A. I refuse to answer as to the number of shares I had.

x-Q. 162. Had you or not, between 1878 and 1880, a sufficient number of shares of this electric light stock to have enabled you to raise 15,000 dollars during any portion of this time by the mortgage or sale of the same?

A. I am not certain as to from 1878 to December, 1879, but afterwards I could have sold shares and
423 have obtained 15,000 dollars, but I would not have sold a share could I have sold it for twenty thousand dollars a share; not that it was worth a cent, but as a matter of principle.

x-Q. 163. How many contracts had you between July, 1878 and 1880, with the Western Union Telegraph Company?

Counsel for Edison objects to the question upon the ground that it is not a cross-examination on any matter contained in the direct
424 examination.

A. I don't know.

x-Q. 164. Had you during this period, between July, 1878, and 1880, a contract with the Western Union Telegraph Company, under which you were to be paid a certain amount in cash each week for experiments, and were to receive in addition thereto the sum of 6,000 dollars a year?

Same objection as to previous question.

A. Yes, sir, I had such a contract; one under

which I was to be paid $100 a week, which money 425
was to be solely used for experimenting on telegraphic apparatus for the Western Union Telegraph Company; the other contract was for payment of $6,000 a year on account of my telephone, 25 per cent. of which was divided among my assistants, the balance used for my family expenses.

x-Q. 165. Had you during this period, any contract with the Western Union Telegraph Company other than these two which you have specified, and
under which you received payments of money? 426

Same objection.

A. No, sir, I cannot remember any.

x-Q. 166. Had you any arrangement with the Western Union Telegraph Company, during this period, in accordance with which they were to pay you sums of money for patents taken out by you and assigned to said company, which sums were to be fixed by appraisement of the value of said
patents? 427

Same objection.

A. Yes, sir.

x-Q. 167. How much money did you receive during this period, as near as you can remember, in accordance with these arrangements?

Same objection.

A. I don't think I received a cent.

x-Q. 168. Did you assign any patents to them in 428
accordance with this arrangement during this period?

Same objection.

A. My impression is that I have. The records of the Patent Office will show.

x-Q. 169. But you think you were not paid for them. Is that it?

Same objection.

A. I think no settlement has been made.

429 x-Q. 170. Had you any arrangement similar to that with the Western Union Telegraph Company, with any other company whatsoever during this period?

Same objection.

A. I don't remember any.

x-Q. 171. Had you any similar arrangement during this period with the Gold and Stock Telegraph Company.

430 Same objection.

A. My telephone contract from which I received $6,000 was a tripartite contract between the Western Union Telegraph Company, the Gold and Stock Telegraph Company and the American Speaking Telephone Company.

x-Q. 172. Did you, or not, during this period receive any sums of money from your foreign patents?

Same objection.

431 A. I do not remember receiving any. I think I paid out a good deal of money on that account.

x-Q. 173. Did you during 1879 or 1880, make a contract with the Western Union Telegraph Company for the sale of your motograph for the sum of $100,000?

Same objection.

A. Yes, sir; in 1880. I think it was late in the fall of 1880. It might have been in the summer of
432 1880. I cannot give the exact date without refreshing my memory from some data.

x-Q. 174. Have you any independent recollection of the dates and circumstances to which you have testified in your direct examination after consultation with your memorandum and scrap-books, other than that which you derived from the same?

A. My memorandum and scrap-books only serve to refresh my memory in part; the longer I testify the more accurate my memory becomes, as I am not in the habit of cramming for examination.

x-Q. 175. Do you remember what were the first preparations which you made for filing an application for a patent upon the electric railway, and when you made them? 433

A. I explained some time in November or December, 1879, about a proposed application for a patent on electrical railway to Major Wilber, who was then visiting my laboratory at various times, familiarizing himself with my business with a view of becoming my solicitor. Some of the papers looking towards an application for a patent were probably 434
made in February or March, 1880, but I am not sure whether the complete application filed in the Patent Office, and now in interference, was completed before April or May, 1880, or not, but I strongly believe that it was completed, or nearly completed, in April, 1880.

x-Q. 176. Did Major Wilber finally prepare the application from the directions thus given him in 1879?

A. Yes, sir; and from further directions in 1880. 435

x-Q. 177. Can you make any estimate of the number of applications for patents made by you between July, 1878, and July, 1880?

A. I can't remember; there might have been as many as fifty or more.

x-Q. 178. Do you know whether or not the worm wheel or cog gearing was broken while it was upon the locomotive?

A. No, sir; it was not broken while on the locomotive. 436

Cross-examination for Field was here closed.

Cross-examination by Chas. S. Whitman, Counsel for Siemens:

Counsel for Siemens states that he conducts his cross-examination without waiving any objections made by him during the direct examination.

x-Q. 179. I understand you to say that you conceived the subject matter of this interference as

437 stated in the office letter declaring the interference
some time in 1878. State all means which you have
of fixing the date when you first conceived the sub-
ject matter of this interference?

A. I have already fully testified on that point
about my trip to the West and return and concep-
tion during the trip, in 1878. As this was the first
holiday I had had in a dozen years it is impressed
well upon my memory.

x-Q. 180. Give the name of the first person to
438 whom you communicated your invention after your
return from the West?

A. Charles Batchelor.

x-Q. 181. Who was the next person to whom you
mentioned the invention after your return from the
West?

A. I cannot remember exactly, but I think it was
Mr. Kruesi.

x-Q. 182. Give the names of all other persons to
whom you communicated the invention during
439 1878.

A. I cannot remember who they were. I gen-
erally talked out, no matter who was present.

x-Q. 183. State the names of those you can re-
member.

A. I can't remember.

x-Q. 184. Do I understand you to say that you
now recollect the name of no one to whom you com-
municated the invention during the year 1878, ex-
cept Mr. Batchelor and Mr. Kruesi?
440 A. I do not recollect the names of the persons
who certainly heard my description of an electric
railroad in 1878 other than Messrs. Batchelor and
Kruesi, but there were many persons around, and I
never concealed my ideas, but talked freely about
them, no matter who was present—a practice which
I have changed lately.

x-Q. 185. Can you remember the names of any of
those who were around when you were talking
about your invention in 1878, except Mr. Batchelor
and Mr. Kruesi?

A. No, sir.

x-Q. 186. State the names of all persons to whom 441
you described or talked of the invention, except
Mr. Batchelor and Mr. Kruesi, prior to May 18th,
1879, the date marked in lead pencil upon Exhibits
1, 2, 3, 4 and 5.

A. I cannot remember all their names. I do not
remember any one in particular. There were a
great many persons round, and whether I talked
with them or not it is difficult for me to say. I
talked out and openly to all.

x-Q. 187. Give the names of any of those who 442
were around, except Mr. Batchelor and Mr. Kruesi,
while you were talking of your invention prior to
May 18, 1879.

A. Martin Force, Francis R. Upton, Thomas
Logan, Charles Flammer, Charles Dean, John Ott.

x-Q. 188. I understand Figure 1 of the drawing of
your application, concerning which you have testi-
fied, represents a series of switches, one connected
to one brush of the commutator and one connected 443
to another brush; are these series of switches as
shown in the drawing illustrated in any one of your
exhibits from 1 to 14, inclusive?

A. The switches are not connected to the two
brushes of the commutator in Figure 1.

x-Q. 189. In Figure 1 are illustrated electro motors
for a track switch; are any such electro motors
shown in any one of your exhibits, from 1 to 14, in-
clusive?

A. They are only indicated by the drawing Ex- 444
hibit No. 6. The wires which proceed from the cen-
tral station out to the junction of the two tracks
serving to convey current from the station to the
switch.

x-Q. 190. In Figure 7 is illustrated a means of
conveying motion to the switch; is any such device
illustrated in any of your exhibits, from 1 to 14, in-
clusive?

A. None of the details of the switch are shown in
the exhibits; but the fact of an automatic, electrical-

445 ly moved switch, operated by current sent over wires, is indicated in Exhibit No. 6.

x-Q. 191. Figure 8 shows a switch lever connected to a frame sliding in ways in which works a cam; is any such device shown in any of your Exhibits from 1 to 14, inclusive?

A. I repeat my answer to question 190.

x-Q. 192. Figure 9 shows electrical switches, levers pivoted to suitable supports, and springs with their curved ends turned upward so as to catch the
446 lower end of the levers; is any such device shown in the Exhibits from 1 to 14, inclusive.

A. Exhibit No. 4 shows circuit controlling levers for manipulating the current on the section of rails immediately fronting the station.

x-Q. 193. Was any such device as that illustrated in Figure 9, reduced to practice by you at Menlo Park or elsewhere?

A. No, sir; not on an electric railroad.

x-Q. 194. In Figure 11 is shown a flange made
447 separately and connected by a web, I suppose, of wood, to which they were bolted, by means of which the axle and body of the car are insulated from the flanges and track: is any such wheel shown in any one of your Exhibits from 1 to 14, inclusive?

A. It is only indicated in my Exhibit No. 11, when a change being made from extra conductors to the ordinary rail necessitates an insulation of the wheel or axle. This would be clearly indicated to
448 an expert to whom was shown Exhibits 11 and 8.

x-Q. 195. Where is a wooden or insulated web shown in Exhibits 8 and 11?

A. It is not shown, but would be indicated by the arrangement of the circuit, that the axle connecting the two driving wheels together was insulated.

x-Q. 196. Figure 12 shows the axle cut in two and connected by a sleeve insulated therefrom and bolts insulated but passing through the halves of the axle;is any such device shown in any one of your Exhibits from 1 to 14, inclusive.

A. No, sir. 449

x-Q. 197. Was any such device used or reduced to practice by you at Menlo Park or elsewhere as that shown in Figure 12?

A. No; the one shown in Figure 11 was thought to be more practicable.

x-Q. 198. In Figure 3 is illustrated a boss or spindle on which bears a commutator brush held by an arm through which the current passes; is any such arm or commutator brush shown in any one of your Exhibits from 1 to 14 inclusive? 450

A. No, sir; these exhibits were made to convey the general idea to Mr. Kruesi, and did not go into minute details; such things being given by word of mouth.

x-Q. 199. In Figures 5 and 6 are shown elbow levers pivoted, and springs tending to close the circuit; is any such device shown in your Exhibits from 1 to 14, inclusive?

A. The reversing arrangement shown in Figure 6 is the equivalent of the reversing arrangement shown 451
in Exhibit 4. Both reverse the current, but the shape of the parts is different.

x-Q. 200. I do not ask you anything about equivalents, but whether the device illustrated in the application is shown in the exhibits?

A. The device in figure 6, and the device shown in Exhibit No. 4, are for reversing the direction of the current, and both devices are only intended for that purpose. Both accomplish the purpose, but the construction as to shape of the parts is dif- 452
ferent.

x-Q. 201. How would you operate the device for reversing the current shown in Exhibit 4.

A. By moving the levers.

x Q. 202. Devices for reversing the current were used prior to your invention, were they not?

A. Yes; but not, I think, in connection with an electric railroad.

x-Q. 203. What difference is there in the operation of a device for reversing the current placed on

453 a locomotive, and a device for reversing the current used with other machines and apparatus?

A. Devices for reversing the current, when used in connection with a dynamo machine, have to be specially constructed, so as to obviate the effects of a powerful electric spark.

x-Q. 204. Devices for reversing the current used in connection with dynamo electric machines, were in use prior to your application of such device to an electric railway, were they not?

454 A. I don't call to mind any; neither do I call to mind any where a reversing device was used in connection with a dynamo machine in the same circuit with a motor.

x-Q. 205. Was the exact device illustrated in figures 5 and 6, the same combination of parts, and the parts acting together in the same way, ever reduced to practice by you at Menlo Park or elsewhere?

A. I do not remember that it differs in any re-
455 spect from that shown in figures 5 and 6. It was originally put on the locomotive and is still on.

x-Q. 206. When were devices exactly similar to those illustrated in figures 5 and 6 first applied to an electric locomotive?

A. The devices were made and applied to the locomotive in the trial of the locomotive at Menlo Park in May, 1880.

x-Q. 207. Are the devices and combination of parts shown in figures 5 and 6, shown in Ex-
456 hibit 15.

A. The handle of the reversing lever protrudes from the box in a line with the knee of the person who has hold of the brake. All the other apparatus, except the handle, is covered by the box.

x-Q. 208. Does the reversing key perform any different functions when mounted upon an electric locomotive, than it would perform when mounted upon a stationary engine?

A. Very slightly different. If at the station, the direction of the current passing through the track

and bobbin would be reversed upon the moving 457
locomotive when the switch was turned; and if the switch was on the locomotive the current through the bobbin would be reversed when the switch was turned; to that extent the functions are the same.

x-Q. 209. In figure 3 is shown a main driving axle upon which is mounted a friction wheel, also a friction pulley mounted upon a shaft of the armature; is any friction wheel upon the driving axle, or any friction wheel mounted upon the shaft of the armature shown in any one of your ex- 458
hibits, from 1 to 15 inclusive?

A. No, sir.

x-Q. 210. Were any such friction wheels reduced to practice by you at Menlo Park or elsewhere, as those mentioned in the last interrogatory?

A. No such reduction to practice on an electric railway was made except on the locomotive at Menlo Park in the May, 1880, trials.

x-Q. 211. Please state the extent of the reduction 459
to practice of such devices upon the electric railway at Menlo Park; I mean by that how long were they in operation and did they perform their work successfully?

A. The locomotive was started with these friction wheels and ran some short distance when one of them broke, and belts were substituted.

x-Q. 212. What was done with them after they were thus broken?

A. They were stored away; I think I have them 460
now at Menlo Park.

x-Q. 213. Were they ever used again or was their use abandoned by you?

A. The wheels were not used again by me. The use of friction gearing has not been abandoned by me, as I have recently designed an electric locomotive containing friction gear. The particular wheels used have not been abandoned by me, except the broken one.

x-Q. 214. Were those friction wheels concerning

461 which you have just testified, used again by you in connection with the electric railway?

A. No, sir; those particular wheels have not been put in use as yet except as testified to.

x-Q. 215. Have wheels exactly similar to them, been put in use as yet; if so when and where?

A. No, sir; not exactly similar to them.

x-Q. 216. In the same figure is shown a swinging frame upon which is mounted a friction pulley; is any such swinging frame shown in any of your ex-
462 hibits from 1 to 14 inclusive?

A. No, sir.

x-Q. 217. Was any such swinging frame ever reduced to practice by you; if so when and where?

A. On the first locomotive in the May, 1880, trials of the electric locomotive at Menlo Park.

x-Q. 218. For how long a time was that swinging frame used on the electric railway at Menlo Park?

A. That particular swinging frame was only used one day, and I am not sure but that the same
463 swinging frame was used with a pulley as a belt tightener since that date up to the present time.

x-Q. 219. Was that swinging frame ever used again in connection with the friction pulleys of which you have before testified?

A. It was not used again in connection with the friction pulleys *e*, *a*.

x-Q. 220. Is there any exhibit in this case which illustrates the manner in which the swinging frame was used, after being used in connection with the
464 friction pulleys?

A. It is partially shown in the photograph Exhibit 15.

x-Q. 221. The combination of the swinging frame and the friction pulleys was given up by you at the same time that you removed the friction pulley, was it not?

A. After one of the grooved friction pulleys broke I took the three off, laid them aside, and substituted belts running on friction pulleys. A friction pulley, however, was kept in the frame to control the

power between the prime motor and the moving mechanism. 465

x-Q. 222. Is that friction pulley which was kept in the frame, shown in any exhibit in this case.

A. No, sir.

x-Q. 223. How long was it kept in the frame?

A. The grooved friction pulley, I do not think was kept in the frame more than a day or so, but I am not absolutely certain, because I am uncertain as to whether the same frame was used with another friction pulley in the manner shown in Exhibit 466
15.

x-Q. 224. How is it shown with another friction pulley in Exhibit No, 15?

A. It is the lever grasped by the man having hold of the brake handle.

x-Q. 225. What function does it there perform?

A. It serves to control the work between the prime motor and the point where the work is to be done.

x-Q. 226. What do you mean by "controlling the 467
work between the prime motor and the point where the work is to be done?"

A. The work to be done is the turning of the driving-wheels on the locomotive. Devices connect these driving-wheels with the source of power and the friction pulley and lever serve to increase or diminish the amount of work done between the point where the work was done and the source of power or motion of the locomotive.

x-Q. 227. In Figure 3 are shown magnets sus- 468
pended from a frame, so that their poles are over and in immediate contiguity to the rails, from which a circuit extends to the arm so that they are in immediate circuit from the track; are these devices shown in any Exhibit from 1 to 15 inclusive?

A. No, sir.

x-Q. 228. Were such magnets suspended from the frame ever reduced to practice in connection with an electric railway by you; if so, when and where?

469 A. I don't remember whether I tried the experiment or not, without searching over all my data, but I call to mind experiments in the laboratory with an electro magnet to ascertain constant attractive power, with which to obtain data as to the constant traction of an electric locomotive, obtainable by these means.

x-Q. 229. I do not ask you anything about experiments; but when and where magnets suspended by a frame as shown in Fig. 3 were first reduced to practice or practically used by you, in connection with or
470 as a part of an electric locomotive or railway?

A. In the middle of May, 1880, I connected two iron bars forming the polar extension of the field magnets of the electro motor, thus being an electro magnet, the ends of the bars being in close proximity to the wheels, which were thus magnetized, thence to the track. But I have already stated in my previous answer that I could not remember without referring to my memoranda
471 whether I had used magnets suspended from a frame precisely in the manner shown in Fig. 3 of my application in interference. I have an impression that I did try such experiment in May, 1880.

x-Q. 230. Who was present at the experiments concerning which you have last testified?

A. I can't remember who was present.

x-Q. 231. If you had made such an experiment, you would have required the assistance of others, would you not?

472 A. Yes, sir, I think I would; but what particular workman arranged the apparatus, or what particular assistant helped me, I cannot now remember, because I am not certain that I ever tried the experiment of suspending an electro magnet precisely in the manner shown in figure 3.

x-Q. 232. With increase of motion of the train the power diminishes, in an electric railway, does it not?

A. No, sir.

By consent, the taking of further testimony was

postponed to Friday, November 25th, 1881, at 10 A. M. 473

Wm. H. Medowcroft,
Notary Public.
New York County.

Pursuant to adjournment, the taking of testimony was resumed on Friday, November 25th, 1881, at 10 A. M., same counsel being present. 474

By Witness: In accordance with my promise I produce photographs of the locomotive and its several parts.

Counsel for Edison puts in evidence photographs marked Edison's Exhibits Nos. 16, 17, 18, 19, 20, 21, 22, 23 and 24 respectively.

By Counsel for Edison:

State briefly what each of these several views represents? 475

A. Exhibit 16 represents part of the mechanism used on the locomotive when worm and worm wheel gears were used. Exhibit 17 shows one of the driving wheels of the locomotive, the rim being insulated from the hub, the current passing down the arms of the spider to a brass cylinder, upon the surface of which a brush rubs, the brush being connected to the motor on the locomotive. Exhibit 18 shows the same character of wheel and contact on the back wheels of the locomotive. Exhibit 19 shows 476
the circuit opening and reversing switch on the locomotive. Exhibit 20 is a side view of the locomotive. Exhibit 21 is another view of the locomotive. Exhibit 22 is a back view of the locomotive. Exhibits 23 and 24 still other views of the locomotive.

Cross-examination by Mr. Whitman resumed.

x-Q. 233. Your prominence in electrical matters during the last five years has caused you frequently to be thrown in contact with electricians and gen-

477 tlemen interested in the application of electricity,
has it not?

A. Very few of them.

x-Q. 234. You have also been in the habit of
meeting gentlemen connected with the press and
conversing with them on the subject of electrical
inventions, have you not?

A. Yes, sir.

x-Q. 235. The large number of patents which you
have taken out during the last few years, make it
478 necessary for you to keep pretty thoroughly posted
in regard to inventions made by others, does it not?

A. No, sir.

x-Q. 236. Are not you supplied at Menlo Park or
at the offices of the companies in which you are in-
terested with publications relating to the latest ap-
plications of electricity?

A. Yes, sir.

x-Q. 237. How long have you been supplied at
Menlo Park or at the offices of the companies with
479 which you are connected with publications relating
to the latest applications of electricity?

A. I have been supplied since 1878, with some
publications which relate to the applications of
electricity.

x-Q. 238. What month in 1878?

A. I think during the whole of 1878.

x-Q. 239. Were you supplied with such publica-
tions in 1877, to any extent?

A. I was supplied with some publications show-
480 ing the applications of electricity in 1877.

x-Q. 240. Please mention the publications relating
to the applications of electricity with which you
were supplied in 1877?

A. The Journal of the Telegraph and Scientific
American.

x-Q. 241. Please mention the publications with
which you were supplied in 1878, from January 1st
to December 31st inclusive?

A. I cannot remember them all. I remember the
London Telegraphic Journal, The Scientific Amer-

ican, The Journal of the Society of Telegraph Engi- 481
neers, and some German and French papers devoted
to science.

x-Q. 242. You were supplied then with about all
the periodical literature published in this country
and abroad, relating to electricity and its applica-
tions?

A. I was supplied with a large portion of it, but
I didn't read it because I couldn't, except the
English, and I had very little time to read that. I
plunged ahead independently of what other people 482
were doing, and the publications were used by my
solicitors as means of reference when one of my
applications was interfered with by the application
of others.

x-Q. 243. Do you refer to solicitors employed by
you in the year 1878?

A. Yes, and later. The intention was to collect
all these publications so that at some time I should
have a complete set of works for hunting up refer-
ences given me by the Patent Office. 483

x-Q. 244. Who were your solicitors in 1878, to
whom you refer?

A. L. W. Serrell.

x-Q. 245. Do you think of any prominent period-
ical publications relating to electricity and the ap-
plications of electricity with which you were not
supplied during the year 1878, from January 1st to
December 31st inclusive?

Counsel for Field and Siemens call atten-
tion to the fact that the witness before an- 484
swering the question refers to memoranda.

A. I was not supplied with *Il Nuevo Cimento*,
and many others of which I have a memorandum.

x-Q. 246. Can you state from memory without
memoranda any other periodical publications relat-
ing to electricity and its applications with which
you were not supplied during the year 1878?

A. The Quarterly Journal of Science.

x-Q. 247. Were you supplied with the same period-

485 ical publications relating to electricity and its applications in the year 1879, with which you were supplied in the year 1878?

A. I have not taxed my memory so that I could use it as a catalogue to my library, and therefore don't remember.

x-Q. 248. Do you recollect any periodical publications relating to electricity and the applications of electricity with which you were furnished during the year 1879; if so, state all which you can remem-
486 ber?

A. I cannot remember with certainty any one periodical publication that I am absolutely certain I took in 1879. I took a great many. I paid no attention to them. They were piled away in drawers and only brought out when any particular thing was desired to be found. Many of the weekly publications were cut up and pasted in scrap books by some person around the laboratory.

x-Q. 249. Who was the person who cut up these
487 papers and pasted the extracts in scrap books?

A. Two young men named Jehl and Herrick, and others whom I do not now recall to memory.

x-Q. 248. Where are those young men whom you have named now?

A. Mr. Jehl is employed by the Edison Electric Light Company, at their test works in Goerck street. I don't know where Mr. Herrick is.

x-Q. 249. Have you any reason to suppose that you were not supplied with the same periodicals relative
488 to electricity and its application in 1879 as in 1878?

A. I have no supposition about it. I don't know whether I was or not.

x-Q. 250. Were these extracts which were pasted in scrap books placed there for your perusal?

A. They were pasted there to form books of reference in future patent cases.

x-Q. 251. Have you referred to any of those scrap books during the direct or cross examination in this case.

A. My counsel brought three scrap books which

were here when I came, and I have glanced over 489
them slightly.

x-Q. 252. Why did you glance over them?

A. To find the date of Mr. Field's patent, as my counsel was under the impression that he saw it in a scrap book.

x-Q. 253. Were you in the habit of reading or glancing over the articles which were pasted in the scrap books?

A. No, sir; I have about seventy-five or a hundred scrap books, and they are not used except by 490
my solicitors to hunt up references. I rarely look at them.

x-Q. 254. Are the parties who make the scrap books or the solicitors who use them in the habit of calling your attention to scraps or articles which they think would particularly interest you?

A. No, sir; everything relating to electricity is cut out and pasted in books under different subject matters.

x-Q. 255. Do you mean that you have a subject 491
matter index for these books, or that articles are arranged according to their subject matter?

A. Articles are arranged according to their subject matter; that is, it is intended that they should be.

x-Q. 256. How are the articles relating to the electric railway arranged?

A. I don't know; I don't remember ever seeing a scrap book devoted to electric railroads. I have never consulted my scrap books on the subject of 492
electric railroads, except last Wednesday, as stated.

x-Q. 257. Are these scrap books used in making examinations as to the novelty and patentability of inventions by your solicitors and others, at or before the time of making application for Letters Patent in your name?

A. No, sir; they are used for the purpose of making arguments and in connection with references given by the Patent Office, and also in relation to previous publication in connection with applications for foreign patents.

493 x-Q. 258. Have you applied for foreign patents for the electric railway; if so, when and where?

A. Yes, sir. I don't know when, and I don't know where.

x-Q. 259. In what foreign countries have patents been granted to you for the electric railway?

A. My impression is that I have a patent in England, France, and some of the Australian colonies.

x-Q. 260. Have you not also a patent in Canada?

494 A. I don't remember.

x Q. 261. Do you remember making application for a patent in Canada—making the oath and signing the application?

A. No, sir. I don't remember; but it is very possible I have applied for a patent in Canada.

x-Q. 262. I understand you to say that searches were made in the scrap-books before making application for foreign patents; were such searches made in the scrap-books before making the application
495 for patents for the electric railway, concerning which you have testified?

A. You did not understand me right. I did not say they were made before applications for patents; I stated that they were used in relation to the previous publication, in connection with applications for foreign patents. I don't remember of any search being made previous to the preparation of the papers of an application for a patent in foreign countries.

496 x-Q. 263. Was Mr. Serrell your solicitor during the years 1878, 1879 and 1880?

A. He was my solicitor during the years 1878 and 1879.

x-Q. 264. Do you remember any conversations with him, regarding the electric railway, during the years 1878 and 1879?

A. I don't recall any.

x-Q. 265. Were you in the habit during the years 1878, 1879 and 1880, of placing machines and inventions on exhibition at State and National expositions?

A. No, sir. I was not in the habit of doing it.

x-Q. 266. Do you remember whether any machines, constructed or invented by you, were placed on exhibition by you or your agents at the Berlin Exposition in 1879? 497

A. Not to my knowledge.

x Q. 267. When did you first hear of the Berlin Exposition in 1879?

A. I think about March, 1880.

x-Q. 268. Do you remember to have heard that at that exposition there was an electric railway, over which as many as 100,000 people were conveyed during the spring and summer of 1879? 498

x-Q. 269. No, sir; I never heard that there was an electric railway at the Berlin Exposition which carried 100,000 people. I remember that there was an electric railway at the Berlin Exposition.

x-Q. 270. Is any description of that railway contained in your scrap-books?

A. I find in one of my scrap-books devoted to electricity and railways, a description of Siemens's electrical railway shown in the Berlin Exposition, in 499
the "Manufacturer and Builder" of October, 1880.

x-Q. 271. Do you remember any other description contained in your scrap-book, besides that to which you have referred?

A. I will refer to the scrap book devoted to railways, and see. I find no description of an electric railway in my scrap book previous to August 16, 1880.

x-Q. 272. Do you take a periodical called "La Nature" or were you supplied with such a paper during the years 1878, 1879 and 1880. 500

A. I don't remember whether I took it in 1878 or '79, but I remember seeing such a paper in 1880. I never remember of having read a word of that journal.

x-Q. 273. Do you remember having your attention called to an article in "La Nature" relating to the Siemens electric railway?

A. No, sir. I never remember seeing an article in "La Nature" about Siemens's electric railway.

501 x-Q. 274. Is "Der Techniker" among the papers and periodicals with which you were supplied in 1878, 1879 and 1880?

A. No, sir; I don't take it.

x-Q. 275. Do you remember of having your attention called to an article in that paper relating to the Siemens electric railway?

A. No, sir.

x-Q. 276. Was the description published in the "Scientific American" of June 5th, 1880, furnished
502 by you, or did you furnish the information from which the article was prepared?

A. The article was not furnished by me.

x-Q. 277. Do you remember conversing with a representative of the "Scientific American" concerning your electric railway?

A. Yes, sir.

x-Q. 279. In that conversation did you draw a distinction between your own railway and that of Siemens?

503 A. I don't remember to have drawn any such distinction. I do not believe that, at the time, I knew how Siemens's electric railway worked.

x-Q. 280. Was the article on "The Future of the Electric Railway" published in the "Scientific American" of June 12th, 1880, based on a conversation between yourself and a representative of the "Scientific American?"

A. I don't know. Mr. Brock, of the "Scientific American," came down to Menlo Park with one of
504 his assistants, rode over the railroad, which I briefly explained to him, remaining only about two hours.

x-Q. 281. Was anything said at that time concerning the Siemens electric railway?

A. I don't remember.

x-Q. 282. Who was the first person in your employ who called your attention to the Siemens electric railway?

A. I don't remember who called my attention to the Siemens electric railway. I don't remember that any description of Siemens's electric railway was

published in this country until after mine was built, 505
that any person could have called my attention to. Some of my assistants might have called to my attention that Siemens was working on an electric railway, but what people are going to do doesn't cling to mind.

x-Q. 283. Do you remember having any conversation with Mr. Kruesi concerning the Siemens electric railway, wherein you stated to him that it would not answer your purpose?

A. No, sir.

x-Q. 284. Do you remember any conversation be- 506
tween yourself and Mr. Batchelor concerning Siemens's electric railway?

A. Not any particular conversation.

x-Q. 285. Do you remember any conversation whatever or any mention of the Siemens electric railway by Mr. Batchelor?

A. I think we talked about his railway after we had got ours going, wondering how he accomplished certain results.

x-Q. 286. Do you remember to have had any con- 507
versation with Martin Force, Francis R. Upton, Thomas Logan, Charles Flammer, Charles Dean or John Ott, concerning the Siemens electric railway?

A. No, sir; I don't remember any particular conversation. I have probably talked to them at times on this subject. I have not talked to these people nor to Mr. Kruesi or Hornig at all regarding electric railway matters for several months, so as to be able 508
to refresh my memory as to conversations, and I have not read the testimony of Mr. Kruesi or Hornig or heard it, so as to refresh my memory of any conversation regarding electric railway matters.

x-Q. 287. You state that the gentlemen mentioned in the last question were around when you were talking of the electric railway in 1879. Do you remember whether either of those gentlemen in 1879 called your attention to any other electric railway than that which you claim to have invented.

509 A. No, sir; I don't remember that they did.

x-Q. 288. Was the construction shown by you in Exhibits 12, 13 and 14 reduced to practice or used for the purpose of supporting an electric railway locomotive by you at Menlo Park or elsewhere?

A. My impression is that the trestle shown in Exhibit No. 12 was used practically at Menlo Park in May, 1880, except the iron bolts. These I do not think were used.

x-Q. 289. For what purpose was a trestle similar
510 to Exhibit No. 12 used at Menlo Park?

A. As a part of the electrical railroad.

x Q. 290. How much of the track was laid upon a trestle similar to that shown in Exhibit No. 12?

A. I should say about a hundred feet.

x-Q. 291. Why were part of the rails laid upon a trestle and part upon the ground?

A. To act as a sample.

x-Q. 292. For how long a time was a trestle similar to Exhibit No. 12 used?

511 A. Since the railroad was built in May, 1880.

x-Q. 293. Did all the trains run over it which made the through trip?

A. Yes, sir.

x-Q. 294. How does the trestle shown in Exhibit No. 12 differ from the ordinary trestles used for steam railways?

A. I don't know.

x-Q. 295. Can you point out any difference whatever between the trestle used in Exhibit No. 12 and
512 trestles which are used in steam railway construction?

A. I have never examined steam railway trestles sufficiently to be able to give an answer.

x-Q. 296. Are the copper wires under the fish plate illustrated in figure 10 of the drawings, forming part of your application in interference, shown in any one of your exhibits from 1 to 14 inclusive?

A. Copper wire is mentioned and estimated in Mr. Kruesi's figures in Exhibit No. 9.

x-Q. 297. I do not ask you about estimates, but

whether copper wire under the fish plate as illus- 513
trated in figure 10 of your application drawings is illustrated by drawing in any exhibit from 1 to 14 inclusive.

A. Only spoken of in the manner I have stated.

x-Q. 298. In figure 4 are shown sprocket wheels, a sprocket chain, a wheel having a grooved face secured to an axle which is mounted in a box adjustably secured to the frame by a screw; is that combination shown in any one of your exhibits from 1 to
15 inclusive? 514

A. No, sir.

x-Q. 299. In figure 14 is shown a section of track insulated from its neighbors but connected thereto by wire conductors, so that upon such section the contact is reversed; is any such combination shown in any of your exhibits, from 1 to 15 inclusive?

A. The method of making the connection and means for doing it are shown in Exhibit No. 4.

x-Q. 300. Would what is shown in Exhibit 4
perform the same functions as what is shown in 515
figure 14 of your drawings?

A. They will and are intended to perform the same functions.

x-Q. 301. For how long a time did your electric locomotive used at Menlo Park run without stopping?

A. The time it took to go from one end of the track to the other, when it was stopped and returned over the same track; this has continued at
intervals since May, 1880, especially in the summer 516
of '80, when it was run almost every day.

x-Q. 302. About how long a time did it take for the locomotive to go from one end of the track to the other?

A. I don't remember the exact time; my impression is that we went over the road and back inside of three minutes.

x-Q. 303. For how long a time did the locomotive remain stationary after making a trip from one end of the road to the other?

517 A. Only a few seconds generally.

x-Q. 304. How long a time did the locomotive remain stationary after making the round trip?

A. When we had a crowd it remained stationary sufficiently to allow one set of passengers to get off and another to get on.

x-Q. 305. How many round trips were ever made consecutively and continuously?

A. I think as many as 15 or 20.

x-Q. 306. Why were not more made than 15 or
518 20?

A. It used to take up valuable time of my men, and it was a free railroad; we didn't run it very often except when people came to Menlo Park who desired to ride on it.

x-Q. 307. Did you ever run the locomotive for a long time continuously, to find out how long you could run it without heating the armature?

A. We have run it hours at a time and the motor was not arranged to be materially heated when
519 doing its work.

x-Q. 308. You could not run it continuously for hours at a time when you had to stop at each end of the road, could you?

A. When I said "continuously," I meant stopping at one end to take a fresh load of passengers on.

x-Q. 309. Is the dynamo electric machine used upon the locomotive the same as that described in an application filed by you in the Patent Office,
520 which was involved in interference with applications of H. Von Heffner Alteneck, Weston, Holcombe, and others?

A. I was not in interference with Von Alteneck and others.

x-Q. 310. Do you not remember filing a disclaimer in an interference in which H. Von Heffner Alteneck was one of the parties, and in which interference priority was awarded against you and in favor of Von Alteneck.

A. I remember having disclaimed something to

keep out of an interference with Von Alteneck. 521
That is, I disclaimed what I had not claimed. I know nothing about an award of priority being given to Von Alteneck.

x-Q. 311. Was the dynamo machine used upon the electric locomotive at Menlo Park the same as that described in the application in which you filed the disclaimer as stated in your last answer?

A. I did not use a dynamo machine on my locomotive at Menlo Park.

x-Q. 312. What kind of a machine did you use on 522
your locomotive?

A. A magneto electro-motor.

x-Q. 313. What distinction do you draw between the magneto electro-motor mentioned in your last answer and a dynamo electric machine?

A. A magneto machine is one whose field magnet is separate from the induction bobbin; a dynamo machine is one in which the field magnet is a part of the circuit of a dynamo bobbin.

x-Q. 314. Was the dynamo electric machine used 523
as a generator at your station the same as the dynamo electric machine described in the application in which you have testified you have filed a disclaimer?

A. I did not use a dynamo electric machine at the station for running the electric railroad.

x-Q. 315. What kind of a generator of electricity did you use at the station?

A. A magneto electric machine whose field magnets were energized by an exterior source of energy
not connected with the railroad. 524

x-Q. 316. Was the machine which you used at the station and which you designate as a "magneto electric machine, whose field magnets were energized by an exterior source of energy, not connected with the railroad," the same as that described in the application in which you have testified you filed a disclaimer?

A. It was very similar.

x-Q. 317. Did it differ in any respect from the machine described in the application in which you filed a disclaimer; and if so in what respect?

thin arm in armature

525 A. The cylinder on which the wire was coiled was made up of thin disks of iron instead of coiled wire, as in the patent 222,881.

x-Q. 318. Was the electro-motor which you mention in your answer to question 312 described in the application for Letters Patent in which you have testified you filed a disclaimer?

A. The bobbin is similar with the exception of iron disks being used, but the field magnet was wound with very fine wire and connected to the
526 source of energy independently of the induction bobbin, as is set forth in figure 14 of the drawing of my application in controversy.

x-Q. 319. Were not the curved bars enclosing the field of force within which the bobbin revolves the same as the bobbin and the curved bars described in the application in which you filed a disclaimer?

A. Yes, sir; they were nearly the same.

x-Q. 320. With what dynamo machines were you familiar in 1872 and 1873?

527 A. The only dynamo that I was familiar with was the Wilde machine.

x-Q. 321. Does the Wilde machine use what is known as a Siemens' armature?

A. Yes, sir.

x-Q. 322. Was it on your way back from California that you first conceived of the invention in controversy?

A. No, sir; it was on my way to California.

x-Q. 323. Your Exhibits Nos. 1, 2, 3, 4 and 5 seem
528 to be made with a peculiar colored ink. Can you state what kind of ink was used, and where you obtained that particular kind of ink?

A. It was an aniline violet ink. In 1876, I devised a copying ink composed of aniline violet and gum dextrine, which was sold in large quantities during that year and since that time for copying purposes.

x-Q. 324. Are you familiar with Mr. Kruesi's handwriting?

A. Yes, sir.

x-Q. 325. Do you know whether he is in the habit of forming the letter "y" with a loop or with a direct down stroke? 529

A. No, sir; I can only tell his writing by its general appearance.

x-Q. 326. If you are familiar with Mr. Kruesi's handwriting, will you please examine Exhibits 1, 2, 3, 4 and 5, and state why the final "y" of the word "May" in each of those exhibits is formed with a loop, and why the final "y" of the word "tramway" is formed with a straight, heavy down stroke? 530

A. I have looked at the exhibits and can't tell why; but by looking at the other Exhibits Nos. 11 and 8, I find that the "y's" in the words "May" and "tramway," in both these exhibits, are alike. I suppose the dates were put on first, and then immediately afterwards, when the papers were collected, he designated them according to what each referred to; but this is only a supposition on my part.

x-Q. 327. You speak of some sketches made in September, 1878; do you know what became of those sketches? 531

A. No, sir.

x-Q. 328. Did you show the sketches made in September, 1878, to anybody; if so, to whom?

A. My impression is that I did, but I am not certain.

x-Q. 329. Is it not your general habit to have such sketches marked by others, as in the case of Exhibits 1, 2, 3, 4 and 5?

A. Yes, sir; in 1877 all sketches were thus witnessed, but after I commenced on the electric light this rule was let up on. 532

x-Q. 330. Were not paper wheels, in which the rim of the wheel is insulated from the hub, well known before you contemplated their use on your electric locomotive?

A. I don't know whether in paper wheels the rim is electrically insulated from the hub or not. I never examined them to ascertain, but I knew that paper wheels had been used on railroads.

533 x-Q. 331. Wheels having a wooden disc between the rim and the hub were used prior to the time at which you contemplated their use, were they not?

A. I don't know of any case of this kind where such wheels have been used on a railroad, except my own.

x-Q. 332. Do you look upon your claims involved in this interference as being of great value?

A. I haven't thought much about the subject. I should imagine them to be of considerable value in
534 the event of commercial introduction on a large scale of electrical railroads.

x-Q. 333. If these claims are valuable, why were they not made by you when you filed the application for Letters Patent involved in this interference?

A. I suppose that they were made.

x-Q. 334. Can you tell me why the language of your claims involved in this interference is the same as that of the phraseology used by Siemens in claiming his invention?

535 A. No, sir; I cannot. My solicitor, Mr. Wilber, can probably be able to identify them.

x-Q. 335. Have you been outside of the United States since January, 1878?

A. Yes, sir.

x-Q. 336. Where and when?

A. I passed through Canada several months ago.

x-Q. 337. Have you been in any other foreign country except Canada since January, 1878?

536 A. No, sir.

x-Q. 338. Where were the axle boxes and journal bearings of the wheels, upon which your locomotive is supported, obtained?

A. I am not sure whether we made them at Menlo Park, or whether we got them from a car-wheel works.

x-Q. 339. What kind of journal bearings did you use for the wheels of your locomotive.

A. Ordinary machine bearings.

x-Q. 340. What kind of a car-axle box did you use?

A. Similar to those used on street cars. 537

x-Q. 341. Did you obtain the car-axle boxes used by you from the same manufacturers who supply street cars?

A. I have already stated that I do not know whether we made the axle boxes at Menlo Park or got them from the parties who made the wheels. And I don't know whether the parties who made the wheels build street cars or not.

x-Q. 342. Having reference to the comparison
which you have seen fit to draw between your Ex- 538
hibits from 1 to 11 and the Siemens electric railway, what means is shown in Exhibits from 1 to 11 for stopping the trains, without any explanation from you?

A. The reversible commutator in Exhibit No. 1.

x-Q. 343. I cannot see any reversible commutator in Exhibit 1; will you please designate which figure on that exhibit you have reference to?

A. I mark it "X."

x-Q. 344. Do you mean to be understood that 539
those pen scratches which you have marked X would be understood by any one to be a reversible commutator without any further explanation?

A. The lever marked X in connection with the words "reversible commutator" as shown on the exhibit would be at once understood by one skilled in the art. It is as clear as the dynamo machine marked B in the same exhibit. The exhibit is not intended to be a working drawing but a rough
sketch serving to convey to an expert certain ideas. 540

x-Q. 345. Were not such reversible commutators well known prior to the time that you contemplated their use in connection with an electric railway?

A. They were well known to me and my assistants, but my impression is, although I am not certain, that reversible commutators were known to others, but not in connection with an electric railway.

x-Q. 346. Having reference to the comparison just alluded to, what means are shown for revers-

541 ing the direction of the train in Exhibits 1 to 11, without the aid of explanation by you?

A. The reversible commutator is the only means shown in my Exhibits 1 to 11 for reversing the direction of the locomotive on the same. I mean the reversible commutator shown in Exhibit No. 1.

x-Q. 347. Having reference to the same comparison, what means for permitting the crossing of the trains are shown in Exhibits 1 to 11 inclusive by the drawings themselves, without any explana-
542 tion from you?

A. The fact that I worked the switches automatically by a current from the station would be indicated to an expert in Exhibit No. 6, but the specific mechanism for accomplishing this object would not be indicated by such exhibit.

x-Q. 348. Were not electro magnets patented or used to close a switch by an electric current communicated to the magnet before you contemplated an electric railway?

543 A. If you refer to a railroad switch I don't call to memory any case of this kind.

x-Q. 349. If the combination of an electric motor and governor is old on a stationary engine, what new function is performed by the governor which you have described in your application?

A. Its new function was to control the speed of an electric railway locomotive. Its other function was to relieve the strain on the belts and the steam engine. I am not aware that a governor has ever
544 been used on an electric engine combined with machines for converting the power of the steam engine into electricity, which electricity is supplied to the electric motor by the converting electric machines. It also performed another function by opening only a portion of the circuit of the electric motor without disturbing the other portion of the electric motor.

x-Q. 350. Why did you find it necessary to refer to a book in answering the last question?

A. I was trying to find an application for a governor to an electro motor having a governor per-

forming the functions I have described, which ap- 545
plication has, I think, been granted to me by the Patent Office, but I couldn't find it, but I find in connection with controlling the railway locomotive a caveat which is dated March 17, 1879, which will elucidate my answers relating to a reversible commutator. The following words occur: "I will mention that for regulating the strength of the current in a Gramme machine that the two commutator springs or brushes may be connected to a
rotating disc, and if placed at right angles to their 546
proper position no current is produced or power absorbed by the machine, but if turned the slightest toward the proper position to obtain the maximum current, then a current is set up in proportion to the movement. Hence, by turning the commutators we may obtain any strength of current we desire without stopping the machine or causing any greater consumption of power than is needed to generate the current."

547

All that part of the answer that is quoted from what is said to be a caveat is objected to by counsel for Siemens unless the caveat itself or a certified copy of it is produced.

Notice is given by counsel for Edison that a certified copy of so much of the caveat referred to as is quoted in the above answer of Mr. Edison will be filed as an exhibit with his testimony.

548

x-Q. 351. Having reference to Exhibit 15, what mechanism is that grasped by the right hand of the operator?

A. It is the friction pulley and lever.

x-Q. 352. What is the object of that friction pulley?

A. For increasing or diminishing the power between the point where the work is to be done and the source of power on the locomotive.

x-Q. 353. The mechanism described in your last

549 answer is not shown in any Exhibits from 1 to 41 inclusive, is it?

A. No, sir; I believe not.

x-Q. 354. Neither is it shown in your application involved in this interference, is it?

A. Yes, sir, it is shown in Figure 3, the handle *f* and wheel *i*; *i* being a friction wheel on the lever *f* for controlling the power between the point where the work is to be done and the source of power in the electric locomotive.

550 x-Q. 355. Can you state about the number of applications for patents you have filed in 1878?

A. I think about ten or fifteen.

x-Q. 356. Can you state about the number of caveats you filed in 1878?

A. I can't remember.

x-Q. 357. Can you state about the number of applications for patents you filed in 1879?

A. I cannot state how many without refreshing my memory; there might have been ten, or there

551 might have been forty.

x-Q. 358. Was the subject matter of any application or caveat filed by you in 1878 or 1879 of more importance than the electric railway?

A. Yes, sir; the applications and caveats related to electric lighting, which in my mind was vastly more important at the time than any electric railway.

x-Q 359. If you were constantly filing applications and caveats in 1878 and 1879, why did you

552 not apply for a patent on an electric railway?

A. First, because I thought it would keep; second, because my costly experiments on the production of economical electro motors and electric converting machines would be valuable when they were worked out to form a part of an electric railway system, and the application in interference was only proposed when by my experiments in electric lighting I had reached a point where I could economically convert motion into electricity and electricity back into motion. When this point was

reached, an electric railway, such as I designed to use, could be made commercially practicable. 553

x-Q. 360. I understand you to say that you first heard that Mr. Siemens was giving attention to the subject of electric railways about the time that you were building your own railway at Menlo Park. From whom did you derive this information?

A. I don't remember.

Cross-examination in behalf of Siemens is here closed.

554

CONTINUATION OF CROSS-EXAMINATION IN BEHALF OF FIELD, BY MR. WHITRIDGE.

x-Q. 361. Please look at Exhibits 21, 22, 23 and 24, and explain the organization and operation of the belt and pulley driving mechanism therein shown?

A. On the revolving induction bobbin of the motor, as shown on the left-hand side of Exhibit 21, was fixed a pulley over which a belt ran; this belt also ran over the large wheel shown on the back of 555
the motor on Exhibit No. 22. On the same shaft as this large wheel was a smaller pulley clearly shown in Exhibits 23 and 24. On this small pulley was another belt, which ran over a larger pulley on the main driving wheels. This pulley is shown in Exhibit 21, just behind the commutator brushes. In Exhibit 23 is shown a lever with a friction wheel, which wheel resting on a belt connected with the main drivers was used to regulate the tracting power between the belt and the friction pulleys on 556
which it ran.

x-Q. 362. Why was so large a wheel used in the rear of the motor?

A. So as to permit of the ordinary speed of rotation of the induction bobbin, and thus obtaining the power and speed required by gearing down, so to speak, to the main drivers.

x-Q. 363. Would not the speed have been regulated or reduced more economically by the use of a smaller band wheel?

557 A. No, sir.

x-Q. 364. Is the belt and pulley arrangement shown in these exhibits as described by you, in all respects the same as that which was used upon the motor in May, 1880?

A. I do not think there has been any alteration, except when these devices have been taken off to try others.

Cross-examination in behalf of Field is here closed.

558

RE-DIRECT BY GEO. W. DYER, COUNSEL FOR EDISON.

Re-d. Q. 365. Referring to your answer to cross-question 102, had you at the time indicated in that question, determined as to the economies resulting in the saving of coal in stationary engines over locomotives?

A. Yes, sir; I had determined that a horse power could be delivered by a motor on to conduct-
559 ors 200 feet from the source of power for much less coal than it would take to produce such power through the intervention of the average modern steam locomotive engine.

Re-d. Q. 366. Referring to cross-questions 125, 126, 127 and 128, have you ascertained what was the actual cost of the electric railway built by you at Menlo Park?

A. The total cost of the railway, rolling stock, charges, operating from the time it was built up to
560 three or four months ago, was a few hundred dollars over 16,000 dollars.

Re-d. Q. 367. Referring to cross-question 132, have you not an independent recollection of the date when the sketches referred to were made, based upon your trip to California and a knowledge of what you did immediately afterward?

Objected to by counsel for Siemens and for Field as leading and suggestive.

A. Yes, sir, I have a recollection that they were

made about the time which the exhibits were dated, 561
which recollection is independent of the exhibits, and I distinctly remember ordering either Batchelor or Kruesi to put dates on the trestle work exhibits and put them over the shelf in our office, which was done the same day, I think, that I ordered it done.

Re-d. Q. 368. Referring to cross-question 163 and 164, state what your pecuniary circumstances were between July, 1878, and 1880, with regard to having any considerable money at any one time.

A. I was embarrassed for want of money during 562
all that period, because my expenses were very heavy and I had very little income during my two years' work on the telephone, and contracted many debts; and as the telephone was not paid for in a lump sum, but in monthly instalments, it took me a long while to pay up. At no time was I in a position during that period to undertake, with my limited means, an experiment costing so much money. I used some money in conducting experiments in electric lighting, which I did not like to 563
charge to the parties in New York who were furnishing money for experiments on electric lighting. Hence I assumed them and paid for them out of my own pocket.

THOS. A. EDISON.

By consent, the taking of further testimony was postponed to Wednesday, December 7th, 1881, at 10 A. M., at same place.

564

WM. H. MEADOWCROFT,
Notary Public,
New York County.

Frank McLaughlin, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows, in answer to questions proposed to him by George W. Dyer, counsel for Edison :

Q. 1. Please state your name, age, residence and occupation ?

A. Frank McLaughlin; age, 36; residence, Oroville, California; occupation, mining.

Q. 2. State whether or not you had occasion in the summer of 1878 to visit Menlo Park frequently ?

A. I had occasion to visit there frequently.

Q. 3. Do you remember the fact of the absence during that summer of Mr. Edison; if so where was it understood that he had gone ?

A. I remember that Mr. Edison was absent and that he was West. I am positive that he was in Colorado.

Q. 4. Do you remember about what time it was that he returned from the West ?

A. It was the latter part of July or commencement of August. I think the latter part of July.

Q. 5. Have you ever heard him explain his system of electric railroads, and if so when was the first occasion of such explanation in your hearing.

A. The first time that I heard Mr. Edison speak of electric railroads was in 1878; I think it must have been in August. I can't say that it was explained fully to me. My knowledge of electricity was so very limited, that I suppose I couldn't have grasped it if it had been explained fully to me.

Q. 6. Please state the time of the day, who was present, and the circumstances under which the explanations were made, so far as you remember them?

A. It was in the evening. There was Mr. Edison, Mr. Batchelor, myself, and, I am almost positive, Martin Force and George Carman; at all events two of the employees, who were there loafing around the table in their shirt sleeves. It was up-stairs in the old laboratory at Menlo Park. We were sitting at the table that we used to call the "phonograph

table." To the best of my belief, we were speaking about sending messages by phonograph. Then the subject drifted into sending messages without wires, and Mr. Edison jokingly said that he had sent messages without wires; that he had sent them by mail. That was what we considered a joke. Then he went on to state that he would soon send them by electricity, by an electric railroad. That was the first I ever heard of an electric railroad. He then went on to explain the electric railroad, making some drawings or rough sketches, which were more directed to Mr. Batchelor.

Q. 7. Can you remember how, in these explanations, he proposed to use electrical power?

A. I don't know how it was to be used. I remember that it was to be generated at stations along the road.

Q. 8 Do you remember, in those explanations, what kind of machine was proposed to draw the trains along?

A. No, sir; I do not.

Q. 9. Do you remember whether any explanation was made at that time by Mr. Edison of particular localities or purposes for which such a road would be well adapted?

A. We all spoke of purposes for which we thought it would be useful. I think Mr. Edison spoke of its use for agricultural purposes, in new countries such as Minnesota and Dakota. He also spoke of carrying messages on an elevated structure. There were so many other suggestions as to uses, that I can't remember who made them or what they were. I remember that I asked Mr. Edison if it could not be adapted for mines.

Q. 10. What kind of an impression did these explanations accompanied by sketches or drawings make upon you as to the degree of perfection to which Mr. Edison had carried in his own mind the subject of electric railways ?

A. I am free to admit that anything which Mr. Edison should tell me, I should feel sure that he was

fully posted on, in lack of any information against it. I mean as applied to electrical subjects.

CROSS-EXAMINATION BY F. W. WHITRIDGE, ESQ., Counsel for Field.

x-Q. 11. This was a very informal gathering about the "phonograph table," on the evening you refer to when I understood you to say you were all "loafing" around the table, was it not?

A. It was an informal gathering; some of us were "loafing," and others at work.

x-Q. 12. How long were you all there together?

A. I think I was there for about half an hour.

x-Q. 13. What were those who were working, working upon?

A. That I couldn't tell.

x-Q. 14. Mr. Edison first spoke of an electrical railway after the talk about sending messages without wires, did he?

A. I understood him to speak of his own electric railway, after the talk about sending messages; yes.

x-Q. 15. Did that idea create much surprise among those about the table?

A. I can't speak for the others; it impressed me very forcibly, indeed.

x-Q. 16. You all began to discuss the matter, I understand you, and to suggest the various purposes to which such a railway might be put?

A. I can't say that we all suggested purposes, or that any of us did, except that I remember my asking if it might not be adapted to a certain purpose.

x-Q. 17. Do you remember any of the purposes which were suggested by any of the others?

A. I don't know whether a question is a suggestion or not; I asked if it might not be used for transporting ore; I don't remember what suggestions were made by others.

x-Q. 18. Do you remember anything that Mr. Edison said on this evening; if so, give his language as near as you can?

A. No, sir; I couldn't give his language in any way; it is just a general recollection.

x-Q. 19. Has this general recollection been refreshed by conversation with any of the others who were there present, recently?

A. No.

x-Q. 20. Can you explain more fully your recollection of Mr. Edison's description of the use of such a railroad for carrying messages?

A. I remember that the track was to be built on poles, and that the small track was to be covered over. I also remember there was some talk as to how the messages were to be stopped. They were to be placed in a cigar-shaped box or chamber to hold them, and then I remember the question came up of how they were to be stopped if they traveled at the great speed Mr. Edison spoke of.

x-Q. 21. Do you remember his speaking of the adaptability of such a railroad as means of communication between a central and branch telegraph offices?

A. No, I do not.

x-Q. 22. Did the others who were in the room seem to be as much struck with the idea as you were?

A. I can't say; it is my impression that Mr. Batchelor had heard of it before.

x-Q. 23. Did you see the sketches which you say Mr. Edison drew in explaining the matter to Mr. Batchelor?

A. I did.

x-Q. 24. Did you hear Mr. Edison say where or when he got his idea of the electric railway for carrying these messages?

A. No, sir, I did not.

x-Q. 25. Do you remember anything about these stations which you speak of on the electric railway?

A. No, sir; only that there were to be stations on the railroad.

x-Q. 26. Your impression of the completeness of this conception of Mr. Edison's is based principally upon your feeling that in any electrical project spoken of by Mr. Edison, he was entirely posted, is it not?

A. It is based on my knowledge of his great knowledge of electricity.

CROSS-EXAMINATION BY CHARLES S. WHITMAN, OF COUNSEL FOR SIEMENS:

x-Q. 27. Have you been in Europe during the last four years?

A. Yes, sir.

x-Q. 28. Please state the times when you were in Europe.

A. In 1878.

x-Q. 29. Have you visited Europe since that time?

A. No, sir.

x-Q. 30. State as nearly as you can the exact date on which you arrived in this country from your last trip to Europe.

A. About the commencement of August, 1878.

x-Q. 31. Do you remember to have heard of an electric railway in Europe?

A. No, sir; I did not.

x-Q. 32. What other electric railways have you heard mentioned besides that of Edison, at any time?

A. I read of one during the last electric exhibition in Paris; also of one by Field in the N. Y. Herald, while I was in California; applied to the elevated railroad.

x-Q. 33. Do you remember to have heard of an electric railway which was in operation at Berlin, in the spring and summer of '79?

A. To the best of my belief I have not.

x-Q. 34. Do you remember whether Mr. Edison stated to you at the meeting concerning which you have testified, the date on which he first conceived the idea of carrying messages by a telegraph wire?

Counsel for Edison objects to the above question upon the ground that it conveys a misstatement of the witness's testimony.

A. He never mentioned carrying messages by a

telegraph wire; the messages were to be transported by electricity on a covered and elevated track.

x-Q. 35. Were you employed at Menlo Park at the time the conversation between you, Mr. Edison and Mr. Batchelor took place?

A. No, sir.

x-Q. 36. How did you happen to be at Menlo Park at that time?

A. It was soon after my trip to Europe, where I had been on private phonograph business, not connected with Mr. Edison, as an employee or agent, and I passed a good deal of time at Menlo Park in 1878 and the commencement of '79.

x-Q. 37. What phonograph business was that to which you allude?

A. It was a private and personal speculation.

x-Q. 38. Was it based on Mr. Edison's patents?

A. It was based on the novelty of the phonograph.

x-Q. 39. What connection did Mr. Edison have with the business concerning the phonograph, of which you have testified?

A. Only his royalties as an inventor.

x-Q. 40. Who is Martin Force, concerning whom you have spoken?

A. He was an employee of Mr. Edison's at Menlo Park.

x-Q. 41. Did you examine the drawings or sketches which were made by Mr. Edison, concerning which you have testified?

A. Not closely.

x-Q. 42. Did you examine them at all?

A. I looked at them during the time Mr. Edison was sketching and explaining them. Being on a subject I was not posted in and rough sketches at that, I could not have understood them any better by examining them more closely.

x-Q. 43. Do you remember whether they were made with ink or with a lead pencil?

A. They were ink.

x-Q. 43. Do you remember whether it was in the

daylight or whether the lamps were lighted in this interview at Menlo Park?

A. My impression is that there were lights in the room, but not at the table we were sitting at. There were lights at the end of the laboratory.

x-Q. 44. The interview occurred then after dark, did it not?

A. It was during the evening. It was not dark there, to the best of my belief.

x-Q. 45. Why were the lights at the end of the laboratory, as you have testified, if it was not dark?

A. It is my belief that the lights were at the end of the laboratory, and only a belief. If they were alight the purpose of their being lit was unknown to me.

x-Q. 46. What heating arrangements, if any, were in the room on the evening to which you refer?

A. None at all; it was in August.

x-Q. 47. Were you in this part of the country or in California during the whole month of August?

A. I was not in California during that month or year.

x-Q. 48. How do you fix the date of the interview as being in August?

A. Because it was just after my return from Europe and about the date of Mr. Edison's return from the West.

x-Q. 49. How long was Mr. Edison absent in the West?

A. I couldn't say.

x-Q. 50. What makes you think the interview was after Mr. Edison's return from the West?

A. Because it was the first time I saw him after his return.

51 x-Q. How do you know that?

A. The same as I know anything; by an effort of memory; that and locating one thing with another.

52 x-Q. You have no other way of fixing the date of this interview, except that it was after Mr. Edison's return from the West and after your return from Europe, have you?

A. My trip to Europe was on such important business to myself that it is impressed so forcibly upon my mind that I can use it as a date to refer to or from.

53 x-Q. Are you connected in business with Mr. Edison at present?

A. In no way.

54 x-Q. Have you been connected in business with him heretofore?

A. No, sir; I have been connected with one of his companies for a short time.

55 x-Q. Have you ever conversed with Mr. Edison concerning Siemens's electric railway?

A. Never.

Frank McLaughlin.

Charles L. Dean, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison:

1 Q. Please state you name, age, residence and occupation?

A. Charles L. Dean; age, forty-two; residence, 61 Penn street, Brooklyn; occupation, machinist.

2 Q. If, during the year 1878, you went into the employ of Mr. Edison at Menlo Park, state in what month of that year, and in what capacity?

A. I think it was in August, as an experimenter.

3 Q. How long did you continue in the employment of Mr. Edison at Menlo Park?

A. I commenced, I think in August, 1878, and continued there until we started the place in Goerck street, which I think was in April, 1881.

4. Q. When you went into the employ of Mr. Edson at Menlo Park, did you have knowledge in any way that he had recently returned from a trip to the West?

A. Yes, sir.

5. Q. If at any time while you were at Menlo Park you heard Mr. Edison explain his electric rail-

way, when was it you first heard such explanation from him?

A. I think it was one night in September, 1878, he explained his idea of an electric railway and spoke about going into it.

6 Q. How full and complete was such explanation.

A. He gave a very full explanation of how he intended to build it.

7. Q. How did he explain that he proposed to build his electric railway?

A. He first spoke about having a central station the same as he was going to have for his light, using the rails for conductors; and he spoke about using the dynamo on the locomotive on wheels. We had quite a long conversation there about the details of it. Of course I can't remember all that was said, but I was quite surprised when he first mentioned it to us. We sat there talking all the evening about the matter, and he made the remark at that time that he expected to build a locomotive as soon as he was in condition to do so.

8. Q. Do you recollect whether or not during that explanation of Mr. Edison's, he illustrated his meaning by sketches or drawings?

A. Yes; he was always very apt to make sketches when he was explaining any new idea that he had, and he made sketches that evening showing what he meant to do with his idea.

9 Q. From the explanations and sketches of Mr. Edison at that time did you understand what kind of an electric railway he proposed?

A. Yes; I thoroughly understood it.

10 Q. Were you familiar with the electric railway which was afterwards built at Menlo Park, in the spring of 1880?

A. Yes, sir.

11 Q. How did that electric railway as built compare with that described and illustrated by Mr. Edison, at the time you mentioned at Menlo Park?

Objected to by counsel for Siemens and counsel for Field, on the ground that it has not been shown that witness is an expert in electrical matters, capable of drawing such a comparison.

A. It was just about the same thing.

12 Q. Do you remember what led up to the explanations of Mr. Edison, on this particular occasion in 1878?

A. His trip West was principally what the conversation started on.

13 Q. In that statement of Mr. Edison, at the time mentioned, did he say when and where he had thought out the matter of an electric railway?

A. Yes; he mentioned that he thought of it on his trip through the West.

14 Q. Did he at the time mentioned explain what he considered would be beneficial or desirable uses of such a railway?

A. He mentioned about the large farms out West, where they had such difficulty in getting their grain to the principal stations; and he thought the railroad could be used in those districts to great advantage.

15 Q. When was your attention next called to this matter of electric railways by any action of Mr. Edison's?

A. I think it was in the summer of 1879; I can't remember what month that he ordered some models of trestles made, and also got out some heavy timber for large trestle work.

16 Q. Please examine the models marked Edison's Exhibits Nos. 12, 13 and 14, and state whether or not those are the models referred to in your previous answer?

A. Yes, sir; those are the models.

17 Q. Do you remember when and by whom they were made?

A. Yes; they were made by a man named Andrews, I am pretty positive. They were made in the shop where I was working.

18 Q. After they were made, what became of them?

A. They were sent in the office where they lay on the table for some time, and were then put on the shelf in the office.

19 Q. Were they there when you left Menlo Park to work at the Goerck street shop?

A. I wouldn't be positive about that, but I think they were. I recollect seeing them there on the shelf, right over where the wash basin was.

Q. 20. You said something about making a full sized section of trestle work. Please explain more about that?

A. They started to make a full sized trestle work. I didn't follow it up to see how far they went on it. I know it lay, and I think it lies yet, down there at Menlo Park.

CROSS-EXAMINATION BY F. W. WHITRIDGE, ESQ., COUNSEL FOR FIELD:

x-Q. 21. What do you mean by saying that you were employed at Menlo Park as an "experimenter?"

A. I call a man an experimenter who is engaged in experimental work.

x-Q. 22. Were any of your experiments made for the purpose of embodying your own conceptions?

A. Well, we used our own ideas to some extent on our experiments.

x-Q. 23. When you received instructions to experiment in a certain direction, do I understand you that you used your own ideas to some extent.

A. Yes; to some extent.

x-Q. 24. You sometimes may, therefore, have supplemented any lack of fulness in the instructions by the use of your own ideas, if I understand you correctly?

A. We didn't always, but sometimes. We always consulted Mr. Edison about what we undertook to do, and had his opinion on it.

x-Q. 25. Were you paid at any time a certain percentage of the money received by Mr. Edison under

some of his contracts, for the purpose of experimenting?

A. No.

x-Q. 26. Who was present at the time when you first heard Mr. Edison explain his electrical railway?

A. I couldn't exactly tell. There were a good many there. I remember Mr. Batchelor and Mr. Edison's nephew. I think a man named Martin Force was there and Mr. Kruesi and several others whom I can't exactly remember.

x-Q. 27. Was Mr. Frank McLaughlin one of those who were present?

A. I don't know positively whether he was present or not.

x-Q. 28. Was any statement made about the cost of the locomotive for such a railway.

A. I don't recollect whether there was or not.

x-Q. 29. Do you remember whether any suggestions were made by those present as to the uses to which such a railway might be put.

A. Yes, I remember his talking about putting it in use out West. I think that Mr. Batchelor made some suggestions. There was a general talk there. I couldn't exactly tell you about what was said.

x-Q. 30. Did you see Mr. Edison make the sketches of which you have spoken?

A. I saw him make some sketches the night we were talking.

x-Q. 31. Did Mr. Edison say when he was going to begin to build this railroad and where?

A. Yes, he said he was going to commence it as soon as he was able to and build it at Menlo Park?

x-Q. 32. Was no estimate made of the cost at that time?

A. I don't recollect of any being made at that time.

x-Q. 33. Did Mr. Edison say when he first thought of this railroad?

A. Yes, he said he thought of it during his trip West.

x-Q. 34. Did he speak of the time and place

when he first thought of it, any more definitely than that?

A. I don't recollect that he did speak just exactly of the day or hour that he first thought of it.

x-Q. 35. Mr. Edison and his employees were at this time all very much occupied with matters relating to the electric light, were they not?

A. Yes.

x-Q. 36. Do you remember if Mr. Edison defined the reason why he was not in a condition to build an electric railway?

A. He hadn't the money.

x-Q. 37. Do you remember his saying that he had not the money?

A. Well, he didn't exactly express it in that way, but it amounted to the same thing.

x-Q. 38. Did it amount also to the same thing as saying that he hadn't the time as well as the money?

A. Yes, I believe that's about the way he expressed himself about it, as near as I can recollect.

x-Q. 39. Do you remember definitely anything that he did say about his condition?

A. Some things I remember and some I don't.

By consent, the taking of further testimony was postponed to Thursday, December 8, 1881, at 10 o'clock A.M.

WM. H. MEADOWCROFT,
Notary Public,
New York Co.

Pursuant to adjournment, the taking of testimony was continued on Thursday, December 8, 1881, same counsel being present, and also Mr. Baldwin of counsel for Field.

x-Q. 40. Do you remember what kind of a gearing apparatus between the dynamo and the driving wheels Mr. Edison spoke of on this night in September as intending to place on his locomotive, or whether he spoke of any at all?

A. He spoke of several devices; one was to use a belt and to use a worm wheel and to use a friction wheel; he also spoke of gearing.

x-Q. 41. Have you had any conversation with Mr. Edison or Mr. McLaughlin within a few days about this conversation in September, 1878.

A. I have not, except that Mr. Edison asked me yesterday or day before if I recollected the conversation about September, 1878; we had no particular conversation about the railway.

CROSS-EXAMINATION BY CHARLES S. WHITMAN, counsel for Siemens:

x-Q. 42. How long have you known Mr. Edison?

A. About 14 years.

x-Q. 43. When did your business relations with him commence?

A. I couldn't exactly tell you; it was when he first started in New York on the Gold and Stock Telegraph Apparatus and on the Automatic Telegraph Company's.

x-Q. 44. What was your business relation with Mr. Edison during the years 1878 and 1879?

A. To assist him with his experiments on the light and other things he had on hand at that time.

x-Q. 45. Were you stationed at Menlo Park during the whole year 1878?

A. Almost all the year.

x-Q. 46. When did you first hear an electric railway of any kind spoken of.

A. When Mr. Edison spoke of it in September, 1878.

47 x-Q. Where were you when Mr. Edison first spoke to you of an electric railway?

A. In the office of his laboratory.

48 x-Q. If others were present at that interview, state who they were?

A. Mr. Batchelor, Mr. Edison's nephew, and I think Mr. Kruesi and several others. I can't exactly recollect who the others were.

49 x-Q. Was that meeting held by lamplight or by daylight?

A. In the early part of the evening.

50 x-Q. When was the next occasion after that meeting that your attention was called to the electric railway by Mr. Edison or any one else?

A. I think it was in the following spring or summer, I couldn't say exactly when. It was when he had the models, Exhibits 12, 13 and 14 made and commenced to experiment on the railroad.

51 x-Q. Are you an electrical as well as a mechanical engineer?

A. I am a mechanic. I don't profess to be an electrician.

52 x-Q. I suppose your avocation as a mechanical engineer renders it necessary for you to keep posted in the latest improvements in mechanical art, does it not?

A. Yes; but I don't have much time to study them up, as my business keeps me very much occupied.

53 x-Q. I suppose your avocation as a machinist throws you into contact with mechanical engineers and persons interested in mechanical improvements, does it not?

A. To some extent.

54 x-Q. You take papers, I suppose, relating to improvements in mechanical applications.

A. Yes, but sometimes never look at them.

55 x-Q. Do you remember to have read in any of these papers an account of any other electric railway except that of Mr. Edison's?

A. Yes, I think it was this summer, and I think in the "Scientific American" that I saw a cut of Siemens's electric railway—the first I ever noticed about an electric railway in a paper.

56 x-Q. Who called your attention to the description or illustration of the Siemens railway in the "Scientific American"?

A. No one.

57 x-Q. I suppose you had heard of the Siemens railway before, hadn't you?

A. I had not.

58 x-Q. Do you remember any conversation between Mr. Edison and Mr. Kruesi in regard to the Siemens railway, in which Mr. Edison stated to Mr. Kruesi that the Siemens railway was not adapted to his purpose?

A. I can't say that I do.

59 x-Q. Have you ever had any conversation with Mr. Edison with regard to the Siemens railway?

A. I don't recollect that he ever mentioned the Siemens railway to me.

60 x-Q. Do you remember a conversation between yourself and Mr. Kruesi with regard to the Siemens railway?

A. I don't remember any conversation regarding the Siemens railway between me and Mr. Kruesi.

61 x-Q. Was it in a copy of the Scientific American for which you subscribed and which was regularly delivered to you from the office of publication that you saw the illustration of the Siemens railway?

A. I can't say positively that it was in the "Scientific American." It was one of the scientific papers I take, and which I have at the office at the present time.

x-Q. 62. What other scientific papers do you take?

A. The "American Machinist" and the "Iron Age?"

x-Q. 63. Did you also take those papers during the years 1878 and 1879?

A. I did not.

x-Q. 64. You have quite a collection of scientific periodicals at Menlo Park, I believe, have you not?

A. Yes, Mr. Edison has a large collection.

x-Q. 65. Do you and others employed by Mr. Edison have access to those publications if you desire it?

A. Yes, we have.

x-Q. 66. Did you also have access to those publications in the years 1878 and '79?

A. Yes.

x-Q. 67. Do you read or speak German?

A. No, sir.

x-Q. 68. Do you remember ever to have seen a description of the Siemens railway in a paper called "Der Techniker?"

A. No, sir.

x-Q. 69. Who was the first person with whom you remember to have conversed regarding the Siemens electric railway?

A. I don't recollect of any one.

x-Q. 70. At the interview between yourself and Mr. Edison, Mr. Kruesi and Mr. Batchelor in September, 1878, do you remember whether Mr. Kruesi or Mr. Batchelor made drawings or suggestions as to the uses to which an electric railway might be applied?

A. I recollect of Mr. Edison making some sketches, but don't know whether Mr. Kruesi or Mr. Batchelor did or not. It was always Mr. Edison's habit to make sketches in explaining any new idea.

x-Q. 71. Do you state that Mr. Edison made sketches at that interview, because it was his habit to make sketches on such occasions, or because you positively recollect having seen him make those sketches?

A. I saw him make them, and it was generally his habit to make sketches when he was talking about any new idea of his.

x-Q. 72. Was he engaged in conversation at the same time he was making those sketches?

A. Yes.

x-Q. 73. How long was he occupied in making these sketches?

A. I couldn't say.

x-Q. 74. Did he use a pencil or pen in making them?

A. I couldn't say positively. I think it was a pen.

x-Q. 75. Do you remember the kind of paper that was used in making those sketches?

A. I can't say. I think it was common pads that we had in the laboratory for that purpose.

x-Q. 76. Were you as well informed upon electrical subjects at the date of that interview as you are now?

A. I was not.

x-Q. 77. How long had you been giving attention to electrical subjects before this interview in September, 1878?

A. I couldn't tell.

x-Q. 78. Tell me as nearly as you can.

A. It is impossible for me to give you any idea about it.

x-Q. 79. How long had you been employed in the construction of machines or apparatus relating to the applications of electricity, prior to the interview with Mr. Edison in September, 1878?

A. I couldn't tell you how long.

x-Q. 80. Had you been so employed?

A. I couldn't tell whether it was one, two or three years; I worked on a great variety of work; some electrical and some mechanical, and never kept any memoranda about the time I worked on any particular thing.

x-Q. 81. What kind of electrical work were you engaged on prior to the interview with Mr. Edison in September, 1878?

A. On the lamp work for the Electric Light Company.

x-Q. 82. Any other electrical work?

A. There might have been, but I can't exactly recollect any other at that time.

x-Q. 83. Had you done any work on a dynamo electric machine prior to the interview with Mr. Edison in September, 1878?

A. I can't say positively, but I think I had.

x-Q. 84. What dynamo electric machine, if any, did you work on prior to the last mentioned interview?

A. I couldn't tell you. So many were being

constructed at that time, it would be impossible for me to pick out any particular machine.

x-Q. 85. Have you ever been abroad—outside the limits of the United States?

A. I have been in Canada.

x-Q. 86. When did you last refresh your memory concerning the interview between yourself and Mr. Edison in September, 1878, before coming into this building to testify in this cause?

A. When he asked me the question the other day, if I remembered the conversation which took place when he came back from the West.

x-Q. 87. State as nearly as you can the conversation which took place between yourself and Mr. Edison at that time.

A. What time?

x-Q. 88. I refer to the conversation which you say took place "the other day?"

A. He merely asked me if I recollected him talking about an electric railway when he came back from the West. I told him I did. That was all that took place in regard to the railroad.

x-Q. 89. Do you now hold or have you held stock in any company formed for working Mr. Edison's patents.

A. I hold stock in the European Electric Light Company.

x-Q. 90. The Exhibits Nos. 12, 13 and 14 could be used as well for an ordinary steam railway as for an electric railway, could they not?

A. I suppose they could.

x-Q. 91. Has any track, except that for an electric railway, been laid at Menlo Park since January, 1878?

A. Not to my knowledge.

x-Q. 92. Where is the man Andrews who made those models?

A. I couldn't tell you.

x-Q. 93. How long is it since you last saw him?

A. It was either in March or April of this year.

x-Q. 94. Do you know whether Mr. Andrews is still employed by Mr. Edison or in connection with him?

A. Couldn't say.

x-Q. 95. How was the room in which the conversation occurred with Mr. Edison in 1878 heated—by a stove or a furnace?

A. I think it was heated by a stove; I won't say positively.

x-Q. 96. Was there a fire in the stove at the time of the interview?

A. Yes, I think there was. I am not positive about that, though.

x-Q. 97. It must have been pretty cool fall weather then, wasn't it?

A. I don't recollect particularly about the weather. I recollect it had been raining.

x-Q. 98. What do you mean by a dynamo electric machine?

A. I mean by a dynamo electric machine, a machine that generates electricity.

x-Q. 99. Do you call any machine used to generate electricity a dynamo electric machine?

A. No.

x-Q. 100. How is electricity generated by a dynamo electric machine?

A. I refuse to answer that question.

C. L. Dean.

Counsel for Siemens, as the witness refuses to answer the question, declines to cross-examine him further.

Counsel for Edison states that the witness had signed the deposition after notice given by counsel for Siemens that he had finished, and before counsel for Siemens made the statement that he would not cross-examine further because the witness wouldn't answer his questions.

FRANCIS R. UPTON, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows, in answer to questions proposed to him by George W. Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and occupation?

A. Francis R. Upton; age, twenty-nine; residence, Menlo Park, N. J.; occupation, manufacturer of electric lamps.

Q. 2. When did you first go into the employ of Mr. Edison, at Menlo Park, and in what capacity.

A. In November, 1878, as mathematician.

Q. 3. When did you first hear from Mr. Edison that he had made any invention in electric railways?

A. In the winter of 1878-'79 he spoke of making electric railroads, as feeders for the main lines of roads running through the wheat regions of the northwest; I think it was in January or February, 1879.

Q. 4. At that time did he give such a description of his proposed electric railway that you understood what its construction would be?

> Counsel for Siemens and Field object to the question as leading and suggestive.

A. I cannot now recollect that, at that time, the specific construction of the railroad was brought up before me. Conversations that I recollect distinctly with Mr. Edison were regarding the field of use for an electric railway, more than regarding its construction.

Q. 5. Did Mr. Edison, after that, request you to make estimates of the cost of construction of an electric railway?

> Same objection.

A. I made some rough estimates as to the comparative costs of electric railroads and narrow gauge roads.

Q. 6. Do you remember when that was?

A. In February or March, '79.

Q. 7. Do you remember whether or not those estimates included an entire electric railway, with proper apparatus and furniture?

> Same objection.

A. The estimates were rough in their nature, and included stations, road bed, tracks, &c., in both cases. They were, however, chiefly regarding running expenses.

Q. 8. Did these estimates include power in both instances?

A. Yes, I recollect that wind mills were mentioned as auxiliary in the case of the electric railroad.

CROSS-EXAMINATION BY MR. BALDWIN, IN BEHALF OF FIELD:

x-Q. 9 Please state what interest, if any, you have in Mr. Edison's inventions or in the companies organized for exploiting them?

A. I hold shares of stock in various electric light companies, and have charge of his factory for manufacturing lamps.

x-Q. 10 Have you not had since 1878, a continued interest in some of Mr. Edison's inventions or in the receipts therefrom?

A. I have, as regards the electric light.

CROSS-EXAMINATION BY MR. WHITMAN, IN BEHALF OF SIEMENS:

> Counsel for Siemens states that he cross-examines without waiving any objections taken.

x-Q. 11. It was your own idea making estimates of the cost of construction of an electric railway, was it not?

A. I made them at the request of Mr. Edison, after a discussion in which I took the ground that the road would not pay.

x-Q. 12. How are you able to fix the date as being

February or March, 1879, when these estimates were made?

A. By recollection of the work that followed after on electric light and by a strong impression that it was winter when the conversation took place.

x-Q. 13. When did you first hear of such a thing as an electric railway?

A. In these conversations with Mr. Edison.

x-Q. 14. You had at Menlo Park, in '78 or '79, a library containing the leading periodical publications on the applications of electricity, did you not?

A. There were a great many odd journals, but few files.

x-Q. 15. Did you have access to this library of scientific publications?

A. Yes.

x-Q. 16. Did all persons at Menlo Park also have access to this library if they desired to use it?

A. Yes.

x-Q. 17. Can you mention the scientific periodical publications which were regularly filed in the year 1879 at the library at Menlo Park?

A. There were some volumes of the "Philosophical Magazine," the "Journal of the Franklin Institute," "Silliman's Journal," the "Scientific American." Mr. Edison was then taking the "Engineer and Engineering, "Electricity," the "Electrician," "Scientific American Supplement," "Nature," "Popular Science Monthly." These are all that I recollect.

x-Q. 18. Do you remember whether "Der Techniker" was filed at Menlo Park during the years 1878 and '79?

A. I do not recollect seeing it.

x-Q. 19. Were the same publications filed during the year 1880 as in 1878 and '79?

A. Yes. I do not mean that the papers were filed in volumes so much as that they were cut and placed in scrap-books?

x-Q. 20. Was the object of cutting them and placing them in scrap-books to arrange the latest information in regard to electrical applications for reference?

A. That was the object, but it woefully miscarried, as the scrap-books were not kept up to date.

x-Q. 21. Do you remember being present at a conversation between Mr. Kruesi and Mr. Edison in the spring or summer of 1879, when the Siemens electric railway was being discussed or mentioned?

A. I recollect that the Siemens railway was a topic of conversation at the Park after its publication, and that we all agreed that there was nothing novel in it; I do not now recollect the special conversation between Mr. Kruesi and Mr. Edison.

x-Q. 22. Who do you mean by "we all" in your last answer?

A. Mr. Edison, Mr. Batchelor, Mr. Kruesi, and myself.

x-Q. 23. What publication do you allude to in your answer to interrogatory No. 21?

A. To the best of my recollection it was in a French journal.

x-Q. 24. Do you remember the name of the French journal?

A. I do not.

x-Q. 25. When did this conversation between yourself and Mr. Batchelor and Mr. Kruesi and Mr. Edison occur?

A. There was no special conversation that I recollect, where all were present.

x-Q. 26. Did Mr. Edison make any mention of the Siemens railway when he gave you instructions to make estimates?

A. The time these estimates were made was, to the best of my recollection, long prior to our knowing that Mr. Siemens was working on electric railways.

x-Q. 27. Did Mr. Edison ever state to you that the Siemens railway was not applicable to his purpose?

A. Not that I recollect.

x-Q. 28. Who first called your attention to the Siemens electric railway?

A. I cannot say.

x-Q. 28. Do you remember when you first obtained a knowledge of the Siemens railway?

A. My recollection is that we had hints of it in newspaper paragraphs in the summer and fall of 1879, and that the first specific account was in the fall of '79; the railroad at this time did not interest me at all, as it was about this time that Mr. Edison was making his first commercial lamps for exhibition to the public, and my time was employed principally in this direction.

x-Q. 29. Do you remember the names of the newspapers which contained the paragraphs to which you have referred?

A. I do not.

x-Q. 30. When did you first hear of the use of the Siemens railway at the Berlin exposition in 1879?

A. My impression is, it was in the New York Herald.

x-Q. 31. Did you call Mr. Edison's attention to this article in the Herald?

A. I do not recollect doing so.

x-Q. 32. It is highly probable that you did call his attention to it, knowing that he was interested in electric railways, was it not?

A. No, as he took the Herald and I took the Tribune.

x-Q. 33. Do you remember who called your attention to the article in the Herald?

A. I do not; I was at that time the "doubting Thomas" on electric railroads and took very little interest in the matter, so that the dates of Mr. Siemens's publication did not make a very strong impression on my mind.

x-Q. 34. The Siemens railway was then pretty thoroughly discussed at Menlo Park, by Mr. Batchelor, Mr. Edison, Mr. Kruesi, and yourself at the time that items were being first published of it in the daily papers, was it not?

A. I do not recollect now any thorough discussion of the Siemens electric railway.

x-Q. 35. It has been stated in the scientific papers that 100,000 persons were transported by the Siemens electric railway cars at the Berlin exposition of 1879. Did you ever happen to meet one of the 100,000 at Menlo Park or elsewhere?

A. Not to have conversation regarding the matter.

x Q. 36. I do not ask whether you met to have any conversation, but whether you met any person who was transported by the Siemens railway cars?

A. Not that I know of.

FRANCIS R. UPTON.

JOHN F. OTT, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and occupation?

A. John F. Ott; age, 31; residence, 134 Prospect street, Newark, N. J.; occupation, employed by the Edison Electric Light Company, in their experimental department, in Goerck street.

Q. 2. When did you enter into the employment of Mr. Edison, and where and in what capacity?

A. I think it was either in the latter part of 1871 or '72; in Newark, N. J., as an instrument maker, and afterward foreman.

Q. 3. Have you been constantly in his employ ever since?

A. No, sir.

Q. 4. When did you enter into his employ for the last time?

A. In either the latter part of September or beginning of October, 1878.

Q. 5. How long then had you been out of his employ?

A. I think about four years.

Q. 6. After you re-entered his employ, in September or October, 1878, did you hear Mr. Edison speak of his electric railway—and if so, when and where was it?

A. Yes; I did; it was at Menlo Park, in the year 1878, after his return from the West.

Q. 7. Fix as nearly as you can the time when that was?

A. I should judge it was about four weeks after his return.

Q. 8. What led up to Mr. Edison's speaking of his electric railway at that time?

A. It being a warm day, we sat on the piazza, in front of the laboratory, and Mr. Edison was cracking some of his jokes about his western trip, and stated that it would be a good idea to build a small electric railway, to be used out in the western countries—and especially a good idea for mining purposes.

Q. 9. Did he then give any reason why such a railway would be good for mining purposes.

A. He did. The reasons were that the electric motor could be made in a much smaller space, and answer the purpose of steam locomotives, as they are low and can be run into shafts where a man can only creep or walk stooping.

Q. 10. Did he explain at that time how the electrical power could be generated.

A. With a stationary dynamo charging the rails, or in other words using the rails as conductors, as the mines are dry enough not to effect any great loss from the escape of electricity.

Q. 11. At that time did he illustrate his ideas by sketches.

A. I did not see him make any sketches.

Q. 12. Was his description at this time so full and clear that you understood what his proposed construction would be.

A. It was.

Q. 13. When next did you have your attention called to his electric railway.

A. Near December 5th, 1878.

Q. 16. In what manner was it so called ?

A. By seeing an article in one of our New York papers stating that some reporter made a remark that it would be a good idea to use horse-car starters, which put me in mind that it would be a good idea to utilize the electric current, which I so mentioned to Mr. Charles Batchelor, whereupon he answered that sketches to that effect had been made by Mr. Edison, and that it would come under that heading.

Q. 17. When next was your attention called to Mr. Edison's electric railway, so far as you remember?

A. Somewhere in the fall of 1878, as I was looking through the drawer for a peculiar drawing that I wanted, I saw some sketches referring to electric railway.

Q. 18. Do you know what became of those sketches?

A. I do not; they always went to the office and there were stowed away.

Q. 19. When did you ever see the models on the table before you, marked Edison's Exhibits 12, 13 and 14?

A. Some time in 1879.

Q. 20. How do you know that they are the same?

A. By nothing more than my recollection; I couldn't state positively that they are the same. But if not, they are *fac similes*, especially No. 14, as that represented sketches at that time circulating around of the elevated railway.

Q. 21. Did you see them made—those or something just like them?

A. I saw them made—that is, something just like them.

Q. 22. Were you at Menlo Park when Mr. Edison's electric railroad was built, and operated there in the spring of 1880?

A. I was.

Q. 23. How did that railroad as a whole compare with that described by Mr. Edison in 1878, at the time you have previously testified?

> Counsel for Siemens and Field object to the question, because it does not appear that the witness is capable of drawing comparisons, such as are stated by the question.

A. All the difference was that this one was built overland instead of running down chutes in mines, and the dynamo being run with a steam engine, while in these western countries water being plentiful, it may as well be utilized for motive power.

CROSS-EXAMINATION BY MR. WHITRIDGE IN BEHALF OF FIELD:

x-Q. 24. Did I understand you correctly to say that you were employed by Mr. Edison as an experimenter?

A. To do both; as a machinist and to assist in experimental work.

x-Q. 25. What do you mean by an "experimenter?"

A. One who is able to carry out and work up such plans as may be given to him; putting them into shape, that they may become practical.

x-Q. 26. Your duties as an experimenter differ from those of a skilled mechanic in that in the carrying out of instructions you might sometimes use your own ideas, did they not?

A. Not further than is required of any good machinist.

x-Q. 27. Who was present when Mr. Edison had this conversation with you on the piazza of his laboratory?

A. The conversation was not directly with me, as there were three or four more of his employees present. I think Charles Batchelor was one. The rest I can't remember.

x-Q. 28. Did any of these employees speak of having heard of an electrical railway before?

A. Not to me.

x-Q. 29. In the conversation did it appear that an electric railway had been heard of by any of them before?

A. Not to my knowledge.

x-Q. 30. Had you ever heard of it before?

A. No, sir; I had not.

x-Q. 31. Was there any general conversation as to the uses to which such a railroad might be put?

A. Yes; there was among the employees.

x-Q. 32. To whom was his description of the railroad at that time directed?

A. To no one particularly, as it came up in a general conversation.

x-Q. 33. How long a time did the conversation occupy?

A. I should judge it did not last over ten or fifteen minutes as he wound up with some of his western jokes, and we all went to tea.

x-Q. 31. Do you mean to say that in this conversation of ten or fifteen minutes, introduced and terminated as you have said by western jokes, that Mr. Edison gave you a complete conception of an electrical railway which only differed from that subsequently built by him, in the particulars which you have specified in your answer to the 23d question?

A. Only as far as principle is concerned.

x-Q. 32. What do you mean by that?

A. By that I mean as giving a general outline of how the power may be obtained and converted, and then transmitted and utilized.

x-Q. 33. Did he state at the same time when he conceived the idea of these principles?

A. Yes; he said the idea struck him very forcibly in visiting some of the western mines.

x-Q. 34. Do you own any shares in any of Mr. Edison's companies?

A. I do not.

x-Q. 35. Have you done so at any time?

A. I have not.

x-Q. 36 Have you been paid at any time

since you have been in Mr. Edison's employ by the receipt of a certain percentage of moneys received by him under any of his contracts?

A. I have not.

x-Q. 37. Did Mr. Edison say anything to you at this time about building an electrical railway. I mean at the time of the conversation you have referred to, in September or October, 1878?

A. Not any more than that he said he thought that he would be competent to carry out such a plan without any trouble.

CROSS-EXAMINATION BY MR. WHITMAN IN BEHALF OF SIEMENS:

x-Q. 38. Have you any way of fixing the date when you entered Mr. Edison's employ the last time?

A. Yes, sir. By a book which I have in my possession, showing an account credited to me on the 26th of October, 1878.

x-Q. 39. Do you know when Mr. Edison returned from the West?

A. As near as I can recollect in August, 1878.

x-Q. 40. When did you first hear of an electric railway of any kind?

A. To the best of my recollection it was in the conversation with Mr. Edison, about which I have testified.

x-Q. 41. When Mr. Edison told you that an electric railway would be good for mining purposes, did he also state to you that an electric railway for mining purposes was suggested to him by a Mr. McLaughlin?

A. No, sir; he did not.

x-Q. 42. State as nearly as you can all persons who were present when your first interview with Mr. Edison took place?

A. I don't believe I can remember any more closely than in the previous statement.

x-Q. 43. Were you also employed at Menlo Park during the year 1879?

A. Yes, sir.

x-Q. 44. You have, I believe, at Menlo Park, a library containing the latest publications and periodicals relating to applications of electricity in useful arts, have you not?

A. Yes.

x-Q. 45. Was that library accessible to you while you were employed at Menlo Park, in 1878 and 1879?

A. To a certain extent it was.

x-Q. 46 What newspaper did you refer to in your testimony?

A. I dont know; I am positive it was a New York paper.

x-Q. 47. Is the slip which you have in your hand the newspaper article to which you refer?

A. Yes, sir.

x-Q. 48. That slip bears the mark of publication, December 5th, 1878, does it not?

A. Yes.

x-Q. 49. The idea of utilizing the electric current for railway purposes occurred to you before it was intimated to you that Mr. Edison contemplated such an application?

A. Yes, sir.

x-Q. 50. Please state the method of utilizing the electric current which occurred to you after reading the article of December 5th.

A. The idea was to place a large electro magnet underneath the car, in such a manner to make it convenient for operating on a mechanical movement, such, for instance, as a clutch or pawl motion pulling on the axles of the wheels of the car whereby assisting the horses in pulling their load on the start.

x-Q. 51. If the first you heard of an electric railway or thought of an electric railway was after December 5th, the date of publication mentioned, why do you state in an[illegible] question 17 that your at-

tention was called to Mr. Edison's electric railway in the fall of 1878?

A. I stated that because it was the first sketch that I had seen, and not what I had heard.

x-Q. 52. I suppose, as other mechanical engineers, you subscribe for papers relating to mechanical subjects, do you not?

A. Yes, I have at periods.

x-Q. 53. What papers did you subscribe for during the years 1879 and 1880?

A. "The Scientific American." That's all I remember.

x-Q. 54. You are in the habit of meeting other mechanical and electrical engineers and consulting and talking over the latest mechanical improvements, are you not?

A. Yes, sir.

x-Q. 55. In your conversations with others, when did you first hear of the Siemens electric railway?

A. That I can't remember.

x-Q. 56. You read accounts of it in the newspapers, didn't you?

A. Yes, sir.

x-Q. 57. Saw the illustrated articles about it, I suppose?

A. Yes.

58 x-Q. Mention some of the papers or scientific periodicals in which you remember to have seen descriptions of the Siemens electric railway, or allusions to it?

A. A German paper, the "Avance of Science."

x-Q. 59. Any other papers?

A. Not that I remember just now.

x-Q. 60. Do you read and speak German?

A. Not fluently.

x-Q. 61. Was "Der Techniker" among the papers to which you had access in 1878 and '79?

A. That I don't remember, as the article I saw in the Techniker, I do not remember the date of.

x-Q. 62. Who called your attention to the article in the Techniker?

A. I happened to pick it up at the newsdealer's.

x-Q. 63. If you took it up at the newsdealer's, I suppose you read it about the date of its publication, did you not?

A. Yes, but I don't remember that.

x-Q. 63 Was the article in the Techniker an illustrated article?

A. As far as I remember, it was.

x-Q. 64. What did the article in the Techniker describe?

A. It described an electric railway.

x-Q. 65. An electric railway invented by whom?

A. I think it was invented by Siemens.

x-Q. 66. Did you call the attention of Mr. Edison to the article in the Techniker describing the Siemens railway?

A. No, sir.

x-Q. 67. Are you not in the habit of calling Mr. Edison's attention to articles which you see which you think would be of interest to him concerning his inventions?

A. Yes, if I consider them noteworthy.

x-Q. 68. Why then did you not call his attention to the article about the electric railway?

A. Because Mr. Edison was in the habit of subscribing for foreign publications, and I didn't think it was necessary for me to repeat the thing to him.

x-Q. 69. When did you first converse with Mr. Edison about the Siemens railway?

A. I don't remember any special conversation with him on that subject.

x-Q. 70. You have heard Mr. Edison mention the Siemens railway, haven't you?

A. Yes. I heard him say that Mr. Seimens was aiming at something in that direction, but it did not conflict with anything in his system.

x-Q. 71. Was that remark about the Siemens railway made by Mr. Edison at the time when he was speaking to you about the application of such a railway to mining purposes?

A. Not that I remember.

x-Q. 72. When was this remark made by Mr. Edison with regard to Siemens electric railway?

A. I think it was some time in 1880, when I was ordered to make a current-reverser according to his sketch, similar to that shown in Exhibit No. 19, that he made this remark.

x-Q. 73. Was that the first current-reverser that was made?

A. That I couldn't say. This was the first that I designed.

x-Q. 74. You were ordered to make the current reverser before the electric locomotive of Mr. Edison was completed, were you not?

A. Yes, sir.

x-Q. 75. How long was it before the electric locomotive was completed that you were ordered to make the current reverser?

A. The locomotive was completed before I had made the circuit reverser, and not as stated in my previous answer, as I then misunderstood the question.

x-Q. 76. Was the locomotive put in operation upon the tracks before you completed the current reverser?

A. Yes, sir.

x-Q. 77. Was the locomotive put in operation in such a manner as to run upon the track before you were ordered by Mr. Edison to make the current reverser?

A. Yes, sir.

x-Q. 78. Did you complete the current reverser, and was it used on any electric locomotive?

A. Yes, sir, I did, and it was used.

x-Q. 79. How many electric locomotives were used at Menlo Park.

A. Only one that I know of.

x-Q. 78. Did you call the attention of any one at Menlo Park or elsewhere to the article in the Techniker of which you have testified?

A. No, sir; I did not.

x-Q. 79. It has been stated that 100,000 people were transported by the electric railway of Siemens at the Berlin exposition in the spring of 1879. Do you remember ever to have met any one of the hundred thousand?

A. I have not, to my knowledge.

RE-DIRECT BY COL. DYER.

Re-d. Q. 80. You have testified on the cross-examination to a conception of utilizing the electric current for railway purposes, and have described the application of an electric car-starter for horse railways, do the two ideas relate to the same construction?

A. They do not.

Re-d. Q. 81. Explain then what you meant by "utilizing the electric current for railway purposes?"

A. What I thought Mr. Whitman meant was that I had a knowledge of such a thing liable to be done and had not suggested any way of doing it, as I misunderstood cross-question 49. What I meant by utilizing the electric current for the electric car-starter was only a temporary starting power and and not a continuous power.

JOHN F. OTT.

By consent, the taking of further testimony was postponed to Friday, December 9th, at 10 A.M.

WM. H. MEADOWCROFT,
Notary Public,
N. Y. Co.

Pursuant to adjournment the taking of testimony was continued on Friday, December 9th, 1881, same counsel being present.

George F. Barker, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and occupation?

A. George F. Barker; age, 46; residence, Philadelphia; profession, Professor of Physics in the University of Pennsylvania.

Q. 2. Did you make a trip to the West with Mr. Edison in 1878; if so, at what time during that year, and how long were you together?

A. Mr. Edison and I went West in that year with the eclipse party of Professor Draper, leaving New York on the 14th of July. The eclipse was observed at Rawlings, Wyoming, on the 29th, and on the evening of the same day Mr. Edison and I left for San Francisco together. We then visited the Yosemite, returned to Rawlings, where we remained a few days and then returned to St. Louis together; we were together from the 14th of July, when we left New York, to about the 20th of August, when we reached St. Louis.

Q. 3. During that trip, did Mr. Edison talk with you upon the subject of electric railways?

A. He did.

Q. 4. Please state whether fully or otherwise?

A. The subject of the use of electricity as a motive power was frequently discussed during our trip, and the application to railroads, both to local and general railroads referred to.

Q. 5. During that trip, did Mr. Edison explain his general proposed mode of construction and operation of electric railways?

Counsel for Seimens and Field object to the question as leading.

A. I have no recollection that any special system peculiar to himself was mentioned at that time; the general method, namely, the use of an electric generator, and an electric motor and electric connection, and the economy of this method of transmitting power, being the subjects discussed.

Q. 6. Do you remember whether or not a variety of uses to which the electric railway might be applied, was also discussed?

Same objection.

A. I have no recollection that any uses to which an electrical railway could be put other than those for which an ordinary railroad is employed, were discussed. The conditions under which electricity could be employed as a motive power, where it is impossible to employ steam, I remember distinctly, were alluded to.

Q. 7. What impression did these statements of Mr. Edison make upon you as to the completeness of his thoughts and suggestions upon the subject of an electric railway?

A. My conviction was as a result of these conversations, that he had paid considerable attention to the subject of the use of electricity as a motive power, and had already in his mind plans for experiment in this direction. This was confirmed by the statement which he made to me, that he intended to devote himself immediately upon his return to the development of electric lighting and electric motors.

Cross-examination by Mr. Whitridge, in behalf of Field:

x-Q. 8. Did you leave Mr. Edison at St. Louis about the 20th of August?

A. He left me there and returned home the second or third day after our arrival.

x-Q. 9. Do you know when he got back to Menlo Park?

A. I do not.

x-Q. 10. Do you remember when you had your first discussion about the use of electricity as a motive power, with Mr. Edison.

A. The first discussion which I had on the trip

referred to was between the 29th of July and the 1st of August, between Rawlings and San Francisco.

x-Q. 11. How long were you in San Francisco?

A. Three or four days.

x-Q. 12. During your stay in San Francisco did you meet or hear of Mr. Stephen D. Field?

A. We did meet Mr. Field upon several occasions, and he showed us many attentions.

x-Q. 13. Do you remember whether, in any of your conversations with him, the subject of the use of electricity as a motive power was discussed?

A. I have no recollection that this subject was alluded to during any of our conferences with Mr. Field.

x-Q. 14. I presume that scientific questions formed the subject of some of your conversations with him at this time, did they not?

A. They did; and especially electrical ones.

x-Q. 15. Do you know that at that time Mr. Field had been experimenting upon the use of electricity as a motive power?

A. I do not.

x-Q. 16. During your conversations with Mr. Edison during this trip, upon the application of electricity as a motive power, do you remember whether the experiments of any persons, for the same purpose, were referred to?

A. I have no recollection that any commercial system for the transmission of power was specifically mentioned. Several well-known laboratory experiments, wherein one magneto or dynamo electric machine was made to drive another, were of course mentioned.

x-Q. 17. Do I understand you correctly that the impression left upon your mind as the result of your conversations with Mr. Edison upon the application of electricity as a motive power, was that he had given that subject attention, and intended upon his return to experiment with the view of developing it and working out the application?

A. What I intended to say is that the impression left upon my mind in consequence of the conversations with Mr. Edison referred to, was that he had arrived at the conclusion, both by experiment and investigation, that the use of electricity as a motive power was commercially practicable and profitable, and that this was the idea which he intended to develope on his return.

Cross-examination in behalf of Siemens, by Mr. Whitman:

x-Q. 18. How long have you been a professor of physics?

A. Since 1873.

x-Q. 19. I suppose your profession renders it necessary for you to keep posted in the latest publications and proceedings of scientific societies, relating to electricity and its applications, does it not?

A. It does, and I endeavor to do so.

x-Q. 20. Did Mr. Edison, in your conversations with him, strike you as a person who was familiar with electricity as a science and with the applications of pure mathematics to the investigation of electrical phenomena?

A. Mr. Edison impressed me then as he has always impressed me, as the best informed man in the practical applications of electricity that I have ever met. In electrical theory he impresses me as being informed with the same thoroughness in directions toward which he has occasion to turn his attention. In mathematical electricity he is a stranger to the methods employed, inasmuch as the mathematics needed for a proper investigation of the subject have not been especially studied by him.

x-Q. 21. In the colleges and schools the study of pure mathematics, algebra, geometry, trigonometry and, perhaps, the differential and integral calculus is considered a preliminary step to the study of electricity, is it not?

A. For the investigation of electrical theory mathematical methods are necessary, and for the

highest practical results they are either directly or indirectly essential.

x-Q. 22. Do you consider that Mr. Edison had the ordinary mathematical knowledge which would be required in a school or college in order to enable a student to investigate electrical truths, theory or phenomena.

A. I do not understand Mr. Edison to claim a knowledge of the mathematical methods of the schools, but the results which he has obtained prove to my satisfaction that his mind is, in its mode of action, essentially mathematical, as he has arrived at results practically more accurate than would have been obtained in the directions in which he has worked by any known formula.

x-Q. 23. Would not you instruct any student who came to you for advice, that he could not obtain a fair knowledge of electricity, in its applications, without first devoting himself to the study of mathematics?

A. I most certainly should not, as experience shows that those who have obtained eminence as practical electricians by means of their mathematical knowledge are the exception and not the rule. A knowledge of facts is the first requisite to their application. From these facts to deduce theories and laws, is the function of mathematical methods. In my opinion, therefore, mathematical knowledge, while essential to the investigator of electrical theory and very desirable for all who have to do with electrical science, is not absolutely so to the practical electrician.

x-Q. 23. You are familiar, I suppose, with what is known as the "Siemens' Armature," are you not?

A. I am, to some extent.

x-Q. 24. Do you remember any other inventions of Dr. Werner Siemens relating to electricity and its applications?

A. I am not familiar with the patents issued to Dr. Siemens for his inventions, but I know that the

scientific researches which he has made have been of the greatest value, and the applications made by the firm of which he is a member, both for electrical measurement and the apparatus of electricity (which doubtless involve the patents mentioned) are universally recognized as of great merit.

x-Q. 25. When were you last abroad, professor?

A. I left this country on the 18th of June and returned on the 10th of November last.

x-Q. 26. Do you remember of hearing, when abroad, of any other electrical railway than that of Edison?

A. I heard of and saw in operation in Paris the electrical railway of Siemens.

x-Q. 27. Will you please describe the construction and operation of that railway?

A. The rails, which, so far as I could observe, were in general like those of the ordinary tramways of Paris, led from the Exhibition Building to the Place de la Concorde. The car was about the size and shape of an ordinary American horse-car. Beneath it was placed a dynamo-electric machine commonly known as the Siemens machine. This communicated power by belts to the axles of the wheels on which the car rested. The electrical current was communicated to the machine by metallic conductors placed upon poles along the curb at the side of the street. The car was furnished with the ordinary switches and brakes. The motive power was supplied in the Exposition Building by a Siemens machine of large size driven by a vertical steam engine of about 25-horse power, as I judged.

x-Q. 28. You saw all this at the Paris Electrical Exposition, did you?

A. I did.

x-Q. 29. Was any other electrical railway capable of commercial use on exhibition at that exposition except that of Siemens?

A. No other electrical railway available in practice or model of any such railway was there exhibit-

ed. Photographs were shown there of Mr. Edison's electric railway at Menlo Park.

x-Q. 30. What caused you to attend the Paris Exposition?

A. My appointment as Commissioner of the United States to that Exposition.

x-Q. 31. Your official position caused you, I suppose, to be thrown in contact with many persons having a knowledge of the latest applications of electricity?

A. It did; and I had the pleasure of meeting many gentlemen eminent in that department.

x-Q. 32. What was the prevailing opinion among scientific men with whom you were thrown in contact in Paris as to who was the discoverer or inventor of the first electric railway put to commercial uses?

Counsel for Edison objects to the question as incompetent, immaterial and not cross-examination as to any matter brought out on the direct examination.

A. I do not remember that this precise point was ever discussed, I myself knowing at the time of no electrical railway in practical use but the Siemens electrical railway from Berlin to Lichterfeld.

x-Q. 33. When did you first hear of the railroad in operation from Berlin to Lichterfeld?

A. I cannot tell definitely. I read in May or June last an account of the completion of the road.

x-Q. 34. Do you remember ever to have heard of any electric railway at Berlin except that from Berlin to Lichterfeld?

A. No other one in practical use.

x-Q. 35. Did you also attend the Berlin Exposition of 1879?

A. I did not.

x-Q. 36. Do you remember to have heard of an experimental electrical railway at the Exposition last mentioned?

A. I remember reading of the experimental electrical railway referred to, but I am not able to recall that it was in connection with that exhibition.

x-Q. 37. Do you remember in what publication you first read of the electrical railway mentioned in your last answer?

A. My impression is that the first notice I saw of it was in the public prints; afterward I saw a notice of it in some scientific periodical, but I am not able to state now what one it was.

x-Q. 38. When did you first hear of an electric railway capable of transporting one or more passengers?

A. The first experiments lacking to the practical use of electricity as a motive power upon railways, that I remember to have read of, were those of Siemens made in Berlin as above referred to. My recollection is that the account which I read was published in the winter of 1879–80.

x-Q. 39. The Siemens electric railway at the Berlin Exposition, over which it has been said 100,000 people were transported in the spring and summer of 1879, was mentioned, I suppose, in the telegraphic dispatches in the daily papers, and among the scientific memoranda of the leading journals before you read the full description mentioned in your last answer.

A. I suppose it was, but I do not remember to have seen any detailed description of it in any scientific periodical accessible to me up to the present time.

x-Q. 40. Mr. Edison, in the conversation concerning which you have testified, did not describe to you the mechanical means of constructing electric railrailways, did he?

A. I do not recollect that anything was said about any specific method of accomplishing the result.

George F. Barker.

CHARLES T. HUGHES, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison.

Q. 1. Please state your name, age, residence and occupation?

A. Charles T. Hughes; age, 35; residence, Menlo Park, N. J.; occupation at present, building an electric railway.

Q. 2. Please look at the portions of railroad rail before you, united at their meeting ends by a fish plate, and state if you ever saw the same before, and if so, when and where?

A. I have; I cut them from the track at Menlo Park, yesterday.

Q. 3. What railroad track did you cut it out from?

A. From the old electric railway.

Q. 4. Did you see this old electric railway laid; did you see the rails laid?

A. I can't say that I saw these particular rails laid, but I saw them in the track.

Q. 5. How early did you see them in the track?

A. I couldn't say exactly, but it was early in 1880 somewhere.

Q. 6. Was it before or after the electrical railway was in operation?

A. Both.

Q. 7. Are you satisfied that this section is taken out of rails which were laid at that time?

A. I am.

The section of rails referred to put in evidence and marked "Edison's Exhibit No. 25."

Counsel for Siemens and Field object to the exhibit as showing nothing involved in the interference.

Cross-examination in behalf of Field is waived.

CROSS-EXAMINATION IN BEHALF OF SIEMENS BY MR. WHITMAN:

x-Q. 8. What electric railway are you engaged in building?

A. An electric railway at Menlo Park for Mr. Edison.

x-Q. 9. What points will that railway connect when completed?

A. Menlo Park and Pumptown.

x-Q. 10. How long will the road be when completed?

A. It will be 2 miles and about 300 feet.

x-Q. 11. Were you engaged in building another railroad at Menlo Park besides this?

A. No, sir.

x-Q. 12. How were you employed when you saw the old electric railway laid, concerning which you have testified?

A. I was purchasing agent for Mr. Edison.

x-Q. 13. General purchasing agent or were you employed to purchase particular things?

A. I was general purchasing agent.

x-Q. 14. Did you purchase the wheels which were used on the electric locomotive at Menlo Park?

A. I did not.

x-Q. 15. Did you ever hear of any other electric railway than that of Edison?

A. I have.

x-Q. 16. What other electric railway?

A. Of the Siemens railway in Berlin.

x-Q. 17. Did some one describe the Siemens railway to you, or did you read about it in the papers?

A. I read about it.

x-Q. 18. In what publication did you read about it?

A. I don't remember.

x-Q. 19. Was the article which you read, describing the Siemens railway, an illustrated article?

A. No, sir.

x-Q. 20. Did you read about the Siemens railway in some paper for which you subscribe yourself?

A. I couldn't say.

x-Q. 21. Where were you when you read the article about the Seimens railway?

A. That I couldn't say.

x-Q. 22. Was the article about Seimens's railway a long article or a short article?

A. I couldn't say as to that either.

x-Q. 23. Did you ever talk to anybody about the Siemens railway?

A. I may have done so, but don't remember to whom or when.

x-Q. 24. When was it you read the article about the Seimens railway?

A. I couldn't say that.

x-Q. 25. It must have been a long while ago if you can't remember anything about it except that the article wasn't illustrated?

A. I remember reading a newspaper article that simply stated the fact that Mr. Seimens was building an electric railway in Berlin. Whether the railway was described in detail or not, I don't remember.

CHAS. T. HUGHES.

CHARLES L. CLARKE, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison.

Q. 1. Please state your name, age, residence and occupation?

A. Charles L. Clarke; age 28½; residence, New York City; occupation, civil, mechanical and electrical engineer.

Q. 2. What are your present duties?

A. I am first assistant engineer of the Edison Electric Light Company, in charge as chief.

Q. 3. If at any time you entered into the employ of Mr. Edison at Menlo Park, please state when it was and in what capacity?

A. February 1st, 1880, as assistant in laboratory. Strictly, when I first went there it was as a mathematician and assistant to Mr. Upton.

Q. 4. Please state what your education and training had been before you went into the employ of Mr. Edison.

A. Graduate from Public High School in Portland, Maine, in 1870; assistant to a civil engineer in Portland, Maine, from December, 1870, to January, 1872; at that time first assistant engineer on the Boston and Maine Railroad; graduate from Bowdoin College, engineering department, 1875, as Bachelor of Science; travelled abroad for the purpose of inspecting engineering works from September, 1875, until May, 1876; employed in teaching English and mathematical branches and in studying engineering science until my employment with Mr. Edison, excepting three months in the spring and summer of 1877, during which time I was in the employ of Mr. A. L. Holly in New York City as a draughtsman.

Q. 5. After you entered into the employ of Mr. Edison at Menlo Park how long did you remain there in his employ?

A. I was in Mr. Edison's employ at Menlo Park until February, 1881, when the Edison Electric Light Company began operations in New York City.

Q. 6. Did you witness the construction and equipment of Mr. Edison's railway at Menlo Park in the spring of 1880.

Counsel for Seimens and Field object to the question as leading and suggesting the date to the witness.

A. Yes.

Q. 7. Please describe the construction, equipment and mode of operation of such railway in detail, having reference, if you see fit, for illustration to exhibits already put in testimony in this case.

A. The electric railway as constructed extended from within about seventy feet of the boiler room of the machine shop and was about three-quarters of a mile long. The road-bed conformed very nearly to the natural surface of the ground, and included curves considerably less than a chain in radius and grades exceeding 150 feet to the mile. Very little ballast was used in grading the line. The sleepers were common cord wood sticks, in most cases merely laid upon the ballast. The line included considerable trestle-work, the sleepers upon which were sawed timber. The rails used were common T rails weighing about sixteen pounds per yard. Mr. Edison determined to construct this road so that the rails could be used as the conductors for the electricity and to ensure more perfect connection between the ends of the rails, connected these ends by a strip of copper placed underneath the fish plate and firmly bolted to the rail with the same.

The dynamos which were the source of electricity for operating this railway, were placed in the machine shop near the engine-room. The cables connected to these dynamos were connected directly to the ends of the rails nearest the machine shop. The ends of the rails on the farther end of the line were left open. Exhibits 15, 18, 20, 21, 23, and 24 accurately represent the railroad and roadbed as constructed and when operated.

In constructing the electric locomotive Mr. Edison used as a source of motive power an electric motor similar to the dynamo electric machines, which furnished electricity for operating the motor. The magnet was mounted horizontally upon two axles, the wheels supporting which and resting upon the rails were composite and consisted of an iron hub and tire, the space between both being strongly constructed of wood to which they were firmly bolted; this wood serving as an insulator between the tire and hub, thereby preventing the current from passing from rail to rail without first going through the armature of the motor. The tire being in connection

directly, and therefore electrically with the rail, and the hub, and all supported thereon, being insulated from the same, a brass spider with three arms was bolted to the side of the tire, but in no way connected to the hub. Projecting from the center of the spider was a cylindrical hub concentric with the axle. The brush made in this instance of copper wires, rested upon this hub on the spider, and established thereby electrical connection between the brush and rail. This brush was insulated by means of wooden support, and connection from it to a desired point was made by means of insulated wire. It being necessary that the armature of the motor should revolve much faster than the driving wheels of the electric locomotive, a system of friction wheels was first adopted to reduce the number of revolutions from the armature to the driving wheels. Owing to the failure of the friction wheels by breakage of the casting, this system was laid one side, and a system of shafts with belts and pulleys was constructed to attain the same purpose.

To reverse the direction of rotation of the motor armature, and therefore the direction of motion of the locomotive, Mr. Edison used a current reversing switch operated by the locomotive driver by a hand lever.

Cars were constructed mounted upon wheels, built like those already described, excepting that the spider and brush were omitted.

The operation of the system was as follows: The dynamo electric machines in the machine shop being in operation, and the conductors before mentioned connected to the ends of the rails near the machine shop, and the lever of the current reversing switch on the electric locomotive in its proper position, the current of electricity flowed from the dynamo machines through one conductor to one rail; from thence to the tires of the locomotive wheels in contact with that rail; then through the three arms of the spider before described, to the brush in contact with the cylinder

thereon; thence by an insulated wire to the current reversing switch, through the switch to the armature, through the armature and by a conducting wire, through the brushes, spider and tires of the wheels of the opposite side of the locomotive and back by the other rail to the dynamo machines. Reversing the current through the motor armature by means of the switch caused the amature to revolve in the opposite direction and the locomotive to reverse its direction of motion.

A correct view of the details of the current reversing switch as constructed is given in Exhibit No. 19. A correct view of same as constructed and placed for operation upon an electric locomotive is given in Exhibits 20, 21, 22, 23 and 24. Correct views of the locomotive wheels with tire insulated from hub, also of spider with cylinder thereon, making contact with wire brush, and insulated wires leading to current reversing switch and armature, are given in Exhibits 17, 18, 20, 21, 22, 23 and 24.

Mr. Edison also had a headlight placed on the locomotive lighted by an electric incandescent lamp, taking its current from the rails by the same means as current was obtained for the motor amature. Besides the electric appliances, were simple brakes for checking or stopping the locomotive operated by hand levers, and a belt tightener operated in the same manner, distinctly illustrated in Exhibit No. 20.

It being desirable that the armature should attain considerable rate of speed before communicating its motion to the driving wheels, the belt tightener before mentioned served the purpose by allowing the belt passing around the pulley on the armature shaft to slip, until the desired rate of speed was attained and then by gradually tightening the belt, also by degrees, to communicate the full motion of the armature to the driving wheels: also to regulate the ratio between the two according as at any time should be necessary.

Q. 8. Please to state what kind of power was used

for driving the stationary dynamo machines in the machine shop ?

A. Steam power from an engine on the premises.

Q. 9. Please to state what amount of electric energy was developed by the stationary dynamo machines, if you can ?

A. In the neighborhood of 30 horse-power as a maximum.

Q. 10. Did you estimate the loss in the conversion of steam power into electrical energy. I mean the first conversion ?

A. No.

Q. 11. Did you estimate the loss in transmission and reconversion at the point of the motor on the electrical locomotive?

A. I did not.

Q. 12. What speed was developed in the locomotive on this electric railway?

A. Forty miles an hour, by judgment.

Q. 13. What was the character and extent of use of this railway in 1880?

A. As to character it was experimental. It was used to an extent, demonstrating by estimate ratios of speed and load, upon grades, level, straight and curved, portions of the time, that such an electric railway was practicable. It was in use for considerable time, carrying people over the line.

Q. 14. Was it open for exhibition to the public, and notorious?

A. It was.

By consent the taking of further testimony was postponed to Saturday, December 10, 1881, at 10 A. M.

WM. H. MEADOWCROFT,
Notary Public,
N. Y. Co.

Pursuant to adjournment, the taking of testimony was continued on Saturday, December 10, 1881, the same counsel being present.

Q. 15. You have stated in your answer to the 13th question that the electric railway of Mr. Edison at Menlo Park was practicable. Will you please give the reasons which lead your mind to such a conclusion.

A. First, because it was proved by repeated trials that the electric locomotive could and did haul cars heavily loaded with people, and sometimes freight, up grades and around curves, which required the development of much power, and at sufficient rate of speed. By the word "sufficient," I mean it to be applied with the same significance with which I would use the word if speaking of railway trains operated or drawn by steam locomotives under the conditions just mentioned. The speed attained on the straight and level portions of the road was also, in like sense, satisfactory.

Second, because said satisfactory results, as to speed attained and load carried, were attained with an electric locomotive which was hastily and imperfectly constructed as regards details and workmanship, simply for the purpose of practically demonstrating what Mr. Edison knew to be feasible.

Third, because it was ready to operate at a moment's notice, with no preliminary adjustments, the starting of the dynamo electric machines in the machine shop being all that was necessary.

Fourth, because it could be operated, and was frequently operated, by persons having no knowledge whatever of electricity or apppliances for using the same in any manner, simple instruction as to using the hand lever connected to current reversing switch being all that was necessary.

Fifth, it was operated under all conditions of road bed, rails and weather, no difficulty being met with in handling loads or attaining satisfactory speed, excepting from such causes as would interfere with the traction of the driving wheels on the rails, these difficulties being such as would interfere with the operation of any railroad.

Sixth, the mechanical appliances on the locomotive for transferring the electrical energy absorbed by the motor into work in hauling the train were simple, direct in action, and not liable to get out of order; easy to be renewed, and in case of failure, could be readily replaced or repaired.

Seventh, because the electric locomotive carried no unnecessary weight in coal and water, its supply of energy never being carried with it, but always directly obtained from the rails.

Eighth, the development of the energy at the dynamo-electric machines was direct and economical.

Ninth, the development of this energy was at any time only slightly in excess of the energy required by the electric locomotive at that time.

Tenth, the locomotive required only one man to operate the same.

Eleventh, the electric railway system is ecomical in operation. In practice, the railroad would be divided into working sections of such length that the loss of electricity in transmitting the same from the center of each section to its two extremities would not be disadvantageous to economy. At this station in the middle of a section, stationary boilers, engines and dynamos would be placed of a power sufficient to supply all electric locomotives which would be operated upon that section at any one time with the electrical energy necessary for said locomotives to develop required power. By using at this station boilers and engines of an economical type and dynamo electric machines of great capacity operated directly by the engines without interposing counter-shafts and belts, a saving is made as follows:

High rate of evaporation per pound of fuel which may be in the comparatively cheaper form of pea and dust coal or slack; economy of steam consumption for the power developed by engines (this economy to be increased by high boiler pressure); absence of loss in friction which would result from transmitting the power to the dynamos through belts;

diminishing loss energy which would appear in the form of heat in the armature; employment of skilled labor to operate the station, therefore saving by intelligent management; by supplying a current from the dynamo electric machines at the station of high electrical pressure and proportioning the electrical conducting parts of the locomotive with reference to the economical reconversion of this current into power. The ratio of the coal consumed under the boilers at the station to the power developed by the locomotive in hauling a train depends therefore upon the economy of steam generation, of steam consumption, of economy in converting power into electricity, of loss by transmitting through the conductors to the locomotive, of leakage between the conductors or from the conductors to the ground, of economy in reconversion. In a steam locomotive the ratio of fuel consumed to the power developed in hauling the train depends upon the economy of steam generation, steam consumption, and losses by friction in the various parts of the locomotive.

Repeated experiments and the authority of engineers show that steam locomotives of the modern and so-called economical types consume from six to nearly nine pounds of fuel for each horse power developed in hauling a train. Careful and repeated experiments made by Mr. Edison and his assistants upon the economy of steam generation with stationary boilers, economy of steam consumption wih modern type of stationary engines, loss in converting power into electrical energy by his form of dynamo electric machine, of loss in transmission of the electricity and maximum leakage thereof which would occur in practice, loss by re-conversion of the electrical energy into power by his electro dynamic machine as used in the locomotive, go to prove that the maximum ratio of coal consumption to power developed hauling the train is five pounds of fuel per horse power. This is the least economical duty of the

electric locomotive. I will summarize as follows: for the steam locomotive 6 pounds of fuel per horse power is the most economical ratio; nearly 9 pounds of fuel per horse power is the mean ratio; the least economical ratio is problematic.

With the electric locomotive five pounds of fuel per horse power is the mean ratio, and 5⅓ pounds of fuel per horse power is the least ratio of economy.

The electric railway system from its simplicity will require fewer operators, and with the exception of the manager of the station, their average intelligence and skill, and consequently wages, will be less for the same power at command than in the steam locomotive system. The cost of oil, waste, renewal and repairs resulting from the simplicity of the system and freedom from complication in details will be materially reduced.

Mr. Edison has proved practically also that dynamos and motors capable of developing and exerting the great power necessary in operating a railroad can be and have been constructed.

Q. 16. Please look at the exhibits put in testimony in this case, marked 1 to 11 inclusive, and state whether or not you understand from these sketches the inventions illustrated in them?

A. Yes.

Q. 17. Comparing these sketches with the construction and system of Mr. Edison as displayed in his electric railway at Menlo Park, about which you have been testifying, what essential difference do you find?

A. None; I find in these exhibits all the essential elements in accordance with which the electric railway at Menlo Park was constructed and operated in the spring of 1880, in detail and as a whole. So far as relates to the system it was the same.

Counsel for Field objects to questions 16 and 17 and the answers thereto as incompetent, and as involving a conclusion, the sketches

referred to in said questions being of themselves evidence as to what they show.
Same objection by counsel for Siemens.

CROSS-EXAMINATION IN BEHALF OF FIELD BY MR. WHITRIDGE.

Counsel for Field states that any portions of the cross-examination which relate to questions which have been objected to are made without waiving such objection.

x-Q. 18. Were any suggestions made by you as to the construction of the electric railway, at any time, which were embodied in the road as constructed.

A. No.

x-Q. 19. Is your description of the electric railroad, which was made largely with reference to photographs of portions of the same which were recently taken, in all respects an accurate description of the road as it was first constructed?

A. Yes.

x-Q. 20. Did you see Mr. Edison make any of the exhibits, numbered from 1 to 11 inclusive?

A. No.

x-Q. 21. Has he ever explained to you what they were intended to represent, respectively?

A. No.

CROSS-EXAMINATION BY MR. WHITMAN IN BEHALF OF SIEMENS.

x-Q. 22. Are you now employed by Mr. Edison at Menlo Park?

A. No.

x-Q. 23. Are they now engaged in building at Menlo Park an electric railway other than that concerning which you have testified?

A. Yes.

x-Q. 24. What is the object of building the railway now being constructed?

A. To make more perfect the details of the system, with special reference to their every day practical commercial use.

x-Q. 25. The former experiments, concerning which you have testified, then, did not sufficiently establish the commercial success of the invention?

A. They did.

x-Q. 26. Why is it necessary then to go to the great expense of building a new railway and rolling stock? Why not continue to use the old one?

A. Because, as has been proved in the case of most inventions, the inventor himself, or parties desiring to use an invention, find that it can be made more satisfactory for use by making alterations in detail or mechanical construction as to size, shape and relative position of the different parts without modifying the principles or combinations of principles upon which the success of the invention, in the first case, depended.

For expample, the locomotive "Rocket," built by George Stephenson, could be used to-day for transporting passengers and freight as well as fifty years ago. Locomotives like the "Rocket" are not used to-day, neither would a mechanical engineer advise their use, considering the fact that we have for the same purposes locomotives as constructed by the shops at the present time, yet between the two there is no difference in principle, reference being had to the source of energy and means by which it is to be made to do work.

x-Q. 27. Is it not a fact that this new railroad is built for the purpose of satisfying capitalists who are not satisfied with the experiments of which you have testified, or the practicability of the invention?

A. Of my own knowledge I cannot state that such is the case.

x-Q. 28. What necessity was there of conducting the experiments, concerning which you have testified, to establish the practicability of an electric railway, when an electric railway over which 100,000 people, it is said, have been transported, had been

put in successful operation in the city of Berlin in the spring and summer of 1879.

Counsel for Edison objects to the question for the reason that there is no proof of the truth of the statement which is made in the question, and it is not admitted, but on the contrary it is denied, that the electric railway of Siemens alluded to was ever put in successful operation at Berlin or elsewhere.

A. At that time, not being directly interested in electricity or connected in a business way with parties so interested, and not having read any of the periodical literature published during that time, or after that time, until Mr. Edison had completed the constructoin of his electric railway embodying the principles according to which he decided it ought to be constructed, I cannot say, or give any reason why any inventor should not attempt the invention of a practical electric railway system.

x-Q. 29. What printed document is that from which you refreshed your memory while testifying?

A. It is an article written by myself, entitled "Edison's Electric Railway Economically Considered," appearing in Van Nostrand's Engineering Magazine, December, 1880.

x-Q. 30. How long have you been an electrical engineer?

A. Since entering into the service of Mr. Edison, February 1st, 1880.

x-Q. 31. The preparation of articles on the subject of an electric railway has made it necessary for you to make a thorough and exhaustive examination concerning the application of electricity to railway purposes, has it not?

A. It has.

x-Q. 32. In making these examinations did you discover who was the first person to put in practical operation, an electric railway?

A. I did not.

x-Q. 33. Did you discover where and when an electric railway was first practically used?

A. I did not.

x-Q. 34. Did you discover that an electric railway had been practically used before the electric railway of Mr. Edison, concerning which you have testified?

A. I discovered that an electric railway had been in operation at an exhibition in Brussells.

x-Q. 35. How did you happen to discover that this railroad has been used at Brussells?

A. I read an account of the exhibition of the same in a slip cut from some periodical.

x-Q. 36. Whose railway was that used at Brussells?

A. Siemens's.

x-Q. 37. Do you remember in what periodical you read the account of the Brussells railway?

A. I do not.

x-Q. 38. When did you first hear of the Siemens railway, of which you have just testified?

A. My first recollection of hearing of the Siemens railway was either during or after the month of May, 1880.

x-Q. 39. Why do you designate May as the month in which you heard of the Siemens railway?

A. Because it did not occur before Mr. Edison's railway was in operation.

x-Q. 40. Do you remember how information concerning Siemens's railway first came to you?

A. Nothing excepting this article, unless by hearsay.

x-Q. 41. How did information concerning the Siemens railway first come to you by hearsay?

A. I have no positive recollection on this point.

x-Q. 42. Your duties as an electrical engineer, and the preparation of magazine articles upon the subject of anelectric railway have made it necessary for you to thoroughly investigate the Siemens railway?

A. All that I ever wrote and all figures given with reference to economy apply to the Edison system alone. I have obtained such ideas of Siemens's railway as came to me through the periodical literature.

x-Q. 43. Please designate the periodical literature concerning which you have testified?

A. It has been miscellaneous, but I am unable to name it.

x-Q. 44. I understand you to testify that you discovered that an electric railway had been in operation in Brussells before Mr. Edison's railway was in operation; did you mention that Brussells railway to Mr. Edison?

> Counsel for Edison objects to the question upon the ground that the witness has not stated that "he discovered that an electric railway had been in operation at Brussells before Mr. Edison's railway was in operation."

A. I have said in previous answers that I discovered that Mr. Siemens had exhibited an electric railway in operation at Brussells; also that said discovery was after Mr. Edison's railway was in operation. I recollect no conversation with Mr. Edison upon the subject of the Siemens railway.

x Q. 45. I now repeat to you question 34, and request a direct answer?

A. Yes.

x-Q. 46. What electric railway was in use prior to that of Mr. Edison's?

A. According to my recollection of the aforesaid article, Siemens's railway.

x-Q. 47. How do you know that Siemens's railway was in use prior to that of Mr. Edison?

A. By the aforesaid published account of the exhibition of the same.

x-Q. 48. Did the account mention the exact date when the Siemens railway was used at Brussells or elsewhere?

A. I do not remember.

x-Q. 49. How then did you get the impression from the account that the Siemens railway was used before that of Edison?

A. Because while I am perhaps not able to remember exact dates when at the time of reading an

article, the subject-matter as embodying a description of the principles on which a machine is constructed and means by which it is operated, impress themselves on my memory, still I am willing to testify as to the priority of one period over another when months intervene.

x-Q. 50. Do you mean that you read this account before Edison's railway was in operation, or that there was some date contained in the account which enables you to swear that you discovered that Siemens's railway was used before that of Mr. Edison?

A. There was some month, season or date which enabled me to place it prior to the operation of Mr. Edison's railway.

x-Q. 51. Was the date which you refer to in your last answer the date of publication of the article?

A. That I do not know.

x-Q. 52. Was the Siemens railway fully described in the article?

A. Yes; in a popular way.

x-Q. 53. Was it an illustrated article?

A. It was.

x-Q. 54. Do you remember how many illustrations the article contained?

A. I think two.

x-Q. 55. Describe those illustrations, if you please.

A. One illustration was a wood-cut showing the electric locomotive and car with passengers thereon, and locomotive driver in position operating the same; as I remember the other it was a line drawing on a large enough scale to show the construction.

x-Q. 56. How many columns of descriptive matter were there in the article?

A. I cannot state definitely.

x-Q. 57. In what language was the article written —English?

A. I don't remember.

x-Q. 58. What languages are you familiar with?

A. English, and can translate German and French.

x-Q. 59. Where were you when you read the article?

A. At Menlo Park.

x-Q. 60. What causes you to testify that you were at Menlo Park when you read the article?

A. Because all my reading, excepting from the daily press, was confined to the periods when I was at Menlo Park, being constantly engaged during that time in scientific work and research.

x-Q. 61. How do you know that the article was not in the daily press?

A. From the illustrations and type as I remember them, and my recollection of the general appearance and style of the article.

x-Q. 62. What peculiarity was there about the type which enabled you to recollect it so distinctly?

A. The type was large and clear, with wide spaces between the lines, in general character such as is used in scientific publications.

x-Q. 63. What was the general appearance of the article concerning which you have testified?

A. The general appearance was that of an article which might appear in "Nature" or the French work "La Lumiere Electrique."

x-Q. 64. How do you account for the fact that you are enabled to recollect so distinctly the type used in printing the article, and yet unable to recollect in what language the article was written, or the name of the paper in which it was published?

A. Because what has fully impressed itself upon my memory is the general appearance of the article and cuts only.

x-Q. 65. I suppose the Siemens railway was the subject of general discussion at Menlo Park, was it not?

A. No.

x-Q. 67. Don't you remember to have heard it discussed there?

A. I have faint recollections of speaking about the Siemens railway while at Menlo Park, with whom I do not recollect.

x-Q. 68. Do you remember what was said about it at the time mentioned in your last answer?

A. I do remember the fact that some conversation in a sarcastic vein passed between myself and some person whom I do not remember about the Siemens electric railway.

x-Q. 69. What occasion was there for sarcasm in discussing the Siemens railway?

A. The facts about the railway as we read and interpreted them from the cuts and article before mentioned.

x-Q. 70. In using the word "we" in your last answer, what persons do you refer to?

A. I refer to the individual previously mentioned.

x-Q. 71. Were the sarcastic remarks referred to made by yourself or the person with whom you were conversing?

A. Both parties; as I recollect, it was an exchange of opinions with no chance for dispute.

x-Q. 72. What was the sarcastic remark made by you at that time?

A. My remarks had reference to the performance of the Siemens locomotive at that exhibition, as described in the before-mentioned article.

x-Q. 73. Why should your remark be sarcastic?

A. In view of the success of the Edison system having been demonstrated.

x-Q. 74. I still fail to understand why your remarks should be sarcastic; please explain further.

A. A comparison of the results obtained by Siemens with those results obtained by the Edison system, simply brought on that vein when talking of and comparing the two.

x-Q. 75. What were the results of the Siemens system to which you refer?

A. Slow speed and light loads, and the fact that from the illustrations and description the whole sys-

tem appeared small and like a laboratory experiment.

x-Q. 76. What was the speed mentioned in the article?

A. I cannot give the exact rate; according to the best of my recollection, six or eight miles an hour.

x-Q. 77. Was this publication, concerning which you have testified, one for which you subscribed yourself.

A. No.

x-Q. 78. Where did you obtain the publication?

A. Among the literature at Menlo Park.

x-Q. 79. Whereabouts was such literature kept?

A. As I recollect, this article referred to was with a pile of scraps to be placed in scrap books, or was in a scrap-book itself.

x-Q. 80. What was the scrap-book devoted to or used for?

A. Scientific articles cut from periodicals.

x-Q. 81. Who had charge of that scrap-book?

A. I do not remember.

x-Q. 82. What was the sarcastic remark made by the party with whom you were conversing?

A. I do not remember the particulars of the remarks.

x-Q. 83. Do you remember what kind of looking man the party was with whom you were conversing?

A. No.

x-Q. 84. Do you remember ever to have met any one who had seen the Siemens railway in operation?

A. No.

x-Q. 85. Did you ever meet Professor Barker?

A. I have.

x-Q. 86. Did you have any talk with him with regard to the Siemens railway?

A. I did not.

x-Q. 87. Were you Mr. Edison's scientific adviser with regard to the electric railway?

A. Yes.

x-Q. 88. You discussed the matter with him often and thoroughly, did you?

A. Yes.

x-Q. 89. You called his attention to everything which would be of interest in regard to the electric railway, did you not?

A. Yes.

x-Q. 90. How do you account for the fact that in all your discussions and talks with Mr. Edison no word passed between you in regard to the Siemens railway?

A. I do not say that no conversation passed between myself and Mr. Edison regarding the Siemens railway, but I have no recollection of such conversation did it ever take place.

x-Q. 91. What kind of a dynamo electric machine was used at Menlo Park in connection with the Edison railway?

A. Edison's dynamo electric machine.

x-Q. 92. Please describe the armature of that machine?

A. The armature consisted of a soft iron cylinder on the shaft. On this cylinder was wound coils of insulated wire. The two ends of these coils were properly connected to the separate bars of a commutator on the same shaft, said commutator being made up of copper bars insulated from one another and arranged in the form of a cylinder.

x-Q. 93. Are you acquainted with what is known as the Siemens armature, described in works on electricity?

A. Yes.

x-Q. 94. What differences can you point out between the Siemens armature and the armature of Mr. Edison, just referred to by you?

A. Symmetrical connection of the coils to the commutator; proper proportioning of the conductivity of the coils, so as to attain a maximum economy in the distribution of the electrical energy upon the circuit; a minimum development of the energy on the armature in the form of heat; prevention of

heating of the mass of the armature and consequent loss of energy; mechanical perfection which assures durability, reliability and economy.

x-Q. 95. You would designate then the Edison armature as an improvement upon an armature of the Siemens type?

A. I designate it as an Edison armature, the outward appearance of which—referring to form—is like the Siemens.

x-Q. 96. Are you acquainted with the machine known as the "Heffner Alteneck machine," described in late electrical publications, and known also sometimes as the "Siemens machine?"

A. Not in detail.

x-Q. 97. Did you ever see such a machine?

A. No.

x-Q. 98. Do you know how the armature of the Heffner Alteneck or Siemens machine is constructed?

A. I am not familiar with the detaits of this machine.

x-Q. 99. Please describe the method of generating the electric current in the Edison machine?

A. The armature is caused to revolve between the poles of the electro magnet; thereby an electrical pressure is induced in the coils around the armature. When the circuit external to the armature and in connection therewith is closed, a current of electricity flows through the armature and external circuit, its intensity depending upon the ratio of this electrical pressure to the total resistence of the circuit.

x-Q. 100. In the Edison machine a cylindrical armature wound with insulated wire revolves within a cylindrical space formed by curvilinear parts of the magnet; does it not?

A. Yes.

x-Q. 101. In the Edison machine how are the coils upon the armature connected with the coils upon the magnet electrically?

A. Mr. Edison's usual method is to connect the coils on the magnet in derived circuit to the external circuit.

By consent, the taking of further testimony is postponed to Monday, December 12, 1881, at 10 A. M.

Wm. H. Meadowcroft,
Notary Public,
N. Y. Co.

Pursuant to adjournment, the taking of testimony was resumed on Monday, December 12, 1881, same counsel being present.

x-Q. 102. In the electric locomotive used at Menlo Park, as illustrated in Exhibit No. 20, please explain how the current from the rail was carried through the wheel to the motor of the locomotive?

A. The tires of the locomotive wheels were electrically insulated from the hubs, and therefore from the rest of the locomotive in a manner already described in my answer to Question 7. This insulation, as before mentioned, preventing a current from passing directly from rail to rail through the body of the locomotive itself. The current of electricity passed from the rail to the tines of the locomotive wheels in contact with that rail, through the arms and to the hub of the spider; then through tho brush (all of which mechanism I have previously described in detail); thence by insulated wire through the current reversing switch; from said switch through the motor armature; thence by insulated conductor to the spiders and tines of the wheels on the opposite side of the locomotive to the other rail.

x-Q. 102. Was the construction described in your last answer essential and requisite to the proper working of the locomotive. I have reference particularly to the insulation of the flanges and tread of the wheel from the hub.

A. Yes.

x-Q. 103. Do you find the appliances made use of in the locomotive experimented with at Menlo Park

for insulating the flange and tread of the wheel from the hub, which I understand you to state are essential to the working of the locomotive, shown in any one of the exhibits which have been submitted to you, marked 1 to 11 inclusive?

A. No.

x-Q. 104. Why then did you state in answer to Question 17, that you found in those exhibits all the essential elements in accordance with which the electric railway at Menlo Park was constructed and operated in the spring of 1880, in detail and as a whole?

A. Because modifications of the means by which a principle itself is applied to use, in most cases, require a modification of details themselves.

x-Q. 105. Is any modification or mechanical equivalent of the devices said to have been used at Menlo Park for insulating the flange and tread of the wheel from the hub thereof, shown in any one of the exhibits concerning which you have testified, from 1 to 11 inclusive?

A. Yes.

x-Q. 106. Please indicate the exhibit you refer to in your last answer?

A. Exhibits 8, 10 and 11.

x-Q. 107. Please describe the devices shown in Exhibits 8, 10 and 11, for insulating the tread of the wheel from the hub thereof?

A. Exhibits 8, 10 and 11 do not show any device for insulating the tire from the hub of the wheel, as interpreted by me.

x-Q. 108. Please describe what you suppose to be a mechanical equivalent of the means used at Menlo Park for insulating the tire from the hub, if they are shown in the exhibits you have referred to?

A. Insulation of the conductor from the rail.

x-Q. 109. What insulation of the conductor from the rail?

A. In said exhibits the conductor is represented as insulated from the rail by some insulating material.

x-Q. 110. If the conductor is insulated from the rail, the current does not pass from the rail to any part of any of the wheels, does it?

A. It may.

x-Q. 111. If the conductor is, as you say, insulated from the rail, how does the current get from the conductor to the rail, as shown in the exhibits referred to?

A. By first passing through the armature.

x-Q. 112. Well, where does the current go after it passes the armature?

A. To the rail.

x-Q. 113. Which of the rails—both of them or one of them?

A. According to my interpretation of Exhibit No. 11, to both.

x-Q. 114. What mechanical means are shown in the exhibits for conducting the current from the armature to the rails?

A. I see none.

x-Q. 115. Your answer then to Question 113 is an exercise of the imagination, and not based upon mechanical devices shown in the exhibits?

A. There is no exercise of imagination on my part in answering the question referred to.

x-Q. 116. Does the current flow from the rail, through the wheel, to the motor, in the exhibits just referred to?

A. Not necessarily.

x-Q. 117. Are any mechanical devices shown in the exhibits referred to by means of which the current can flow from the rail, through the wheel, to the motor?

A. No.

x-Q. 118. If no mechanical devices are shown in the exhibits referred to by means of which the current can flow from the rail through the wheel to the motor, why do you say that you find in those exhibits mechanical equivalents of the devices said to have been used at Menlo Park for causing the current to pass from the rail through the wheel to the motor?

A. I have not said the current passes from the rail, through the wheel, to the motor, but have said that it does not necessarily pass in that direction.

In Exhibit No. 11, as drawn and interpreted by me, unless mechanical means were taken to connect the armature to the tires of the wheels and rails, the electrical circuit would be incomplete. A device is shown connecting the conductor between the rails to the locomotive, but details of its connection to the armature are omitted. The motor without a complete circuit or means for making the same would be inoperative, and in this case no mechanical means are to be supplied other than the commutator brushes and connecting wires.

Exhibit No. 10 I am able to interpret in the same manner.

x-Q. 119. The object of insulating the flange and tread of the wheel from the hub thereof in the locomotive used at Menlo Park, was to cause the current to flow from the rail which supported the wheel, through the wheel to the motor, was it not?

A. Yes.

x-Q. 120. Are any mechanical devices shown in Exhibits 8, 10 and 11, which have it for their object to cause the current to flow from the rail, through the wheel resting on the rail, to the motor?

A. Yes.

x-Q. 121. Please designate the mechanical devices shown in those exhibits which cause the current to flow from the rail, through the wheel resting on the rail to the motor of the locomotive?

A. According to my interpretation of Exhibit No. 11, if the electrical pressure be in the direction of the wheel from the rail, the current will flow from the rail to the wheel; thence from the wheel, or part connected therewith, through the armature to the support holding the device making connection with the conductor, shown on the left of the sketch. The portion of the circuit necessary for the flow of the current in the direction described, which is omitted in the sketch, being the commutator brushes.

x-Q. 122. I do not ask you to exercise your imagination or for an interpretation not based upon what is actually shown in the exhibits, but what I do ask, is, as stated in the last interrogatory, that you will please designate the mechanical devices, if any, shown in those exhibits, which cause the current to flow from the rail, through the wheel resting on the rail to the motor of the locomotive?

A. No mechanical devices did cause, as stated in the question, the current to flow in the direction mentioned in the question, but if the electrical pressure were in the direction stated in my last answer, the current would flow in the direction and through the mechanism before described, upon closing the circuit by means of the commutator brushes, which have been omitted in this sketch. It requires no imagination, I trust, on my part, to place commutator brushes where they belong.

x-Q. 123. In your answer to Question 7, you say that in the railway used at Menlo Park, Mr. Edison connected the ends of the rails by a strip of copper placed underneath the fish plate and firmly bolted to the rail with the same; in any of the exhibits from 1 to 11, inclusive, is any such connection of the rails shown?

A. I see none.

x-Q. 124. Is any mode of insulating the rails shown in the Exhibits 1 to 11, inclusive?

A. In Exhibits Nos. 3, 6, 8, 10 and 11, the rails are shown as insulated.

x-Q. 125. How does that method of insulation differ from the way in which the rails are insulated in an ordinary steam railway; say, for instance, the elevated railways in this city?

A. I see no difference.

x-Q. 126. In the dynamo electric machine used at Menlo Park, for generating current to the rails, and electric locomotive, how were the conducting wires, wound lengthwise of the cylindrical armature, kept separated?

A. By means of the insulating material wound on the wires and cloth for insulation between the coils.

x-Q. 127. In the same dynamo electric machine, were the coils of the curved branches of the electro magnets in an electrical circuit from the commutator to the terminus of the machine?

A. If by "curved branches of the electro magnets" are meant the portion surrounding and enclosing the armature, they were not.

x-Q. 128. How were the coils magnetizing the curved branches of the electro magnets supplied with electricity?

A. I think the coils were connected in derived circuit with the external circuit leading to the rails.

x-Q. 129. In the same dynamo electric machine there was a cylindrical armature coiled with insulated wire wound longitudinally on the exterior thereof, was there not?

A. Yes.

x-Q. 130. This cylindrical armature coiled with insulated wire wound longitudinally on the exterior thereof was caused to rotate between the curved branches of the electro-magnet, was it not?

A. Yes.

x-Q. 131. Why were the bars of soft iron which were rendered magnetic by the current of electricity transmitted through the coils, made of a circular curvature in such manner as to form curved branches?

A. To conform to the shape of the armature.

x-Q. 132. Why was it necessary that they should conform to the shape of the armature, on the outside?

A. To make the field of magnetism of a maximum strength.

x-Q. 133. How was the rotating cylinder armature which revolved between the curved portion of the bars made to rotate?

A. By means of pulley on the armature shaft and belt and pulley from counter shaft.

x-Q. 134. Was the cylinder over which the insulated conducting wires were wound lengthwise formed as described in Mr. Edison's patent for magneto-electric machines by winding soft iron wires in such a manner as to form an annular cylinder?

A. I am quite postive it was not.

x-Q. 135. Do you remember about how many groups of insulated conducting wires were wound lengthwise upon the cylinder?

A. As I remember, six.

x-Q. 136. Were the coils kept separate by radial projections at each end of the cylinder?

A. Yes.

x-Q. 137. Were the convolutions of the insulated conducting wires wound on the outer periphery of the cylinder made to bend round in such a manner as to clear the shaft?

A. Yes.

x-Q. 138. Were the terminals of the conducting wires wound lengthwise of the cylinder secured to insulated bars on the rotating commutator?

A. Yes.

x-Q. 139. Were these bars arranged cylindricall y around the shaft on which the armature was fixed?

A. Yes.

x-Q. 140. How many brushes were made to bear upon the insulated bars?

A. Two.

x-Q. 141. Were these brushes fixed on insulated supports?

A. Yes.

x-Q. 142. How were the brushes or insulated supports on which they were placed connected to the terminals of the machine?

A. They were connected directly to the terminals of the machine by short leading wires.

x-Q. 143. In the same dynamo machine, as the cylinder rotated, a succession of electric currents was caused along the wires of the successive coils upon the cylinder, I suppose?

A. I will state more correctly that a succession of

electrical pressures were created in the successive coils on the armature.

x-Q. 142. The currents thus generated were transmitted to the insulated bars on the commutator and successively carried to the metallic brushes?

A. Yes.

x-Q. 143. Did the current or part thereof thus generated pass from the brushes to the coils of the electro-magnet and increase its magnetism?

A. A portion of the current, if the magnets were in derived circuit, as I have already said I think they were, did pass through the coils of the magnet, but did not necessarily increase the strength of the magnet.

x-Q. 144. What difference is there between the dynamo-electric machine, as described thus far in your cross-examination, and the dynamo-electric machine, known as the Siemens or Heffner Alteneck machine, and shown in the drawings of Siemens involved in this interference?

A. I have not seen the drawings referred to.

x-Q. 145. Your profession as an electrical engineer renders it necessary for you to thoroughly familiarize yourself with the leading dynamo-electric machines described in works upon the subject of electricity and periodical articles, does it not?

A. Yes, to the extent that time not required in active professional duties will permit me to do so.

x-Q. 146. I suppose you have often read accounts of the Seimens or Heffner Alteneck machine, which is so extensively used abroad, have you not?

A. Yes.

x-Q. 147. Does the machine used at Menlo Park, so far as it is described in your cross-examination, differ in any essential particular from the Siemens or Heffner Alteneck machine?

A. As far as answers to questions in my cross-examination are concerned, I think there is one difference.

x-Q. 148. Please state what is that one difference?

A. Where the Siemens machine and its use have

come to my knowledge, the magnet coils have formed a portion of the main external circuit.

RE-DIRECT BY COL. DYER, IN BEHALF OF EDISON:

Re-d. Q. 149. Referring to your answers to cross-question 103 and subsequent questions immediately following with regard to details of construction and mode of operation illustrated in Edison's Exhibits, 1 to 11, inclusive—state whether or not, at the date of such exhibits, namely, May, 1879, commutators and the mode of applying them, were not well known among electricians?

A. Yes.

Re-d. Q. 150. State whether or not, at the same date, insulated railway car wheels, also, were well known?

A. Yes.

Re-d. Q. 151. Also, answer as to electrical brushes?

A. Yes.

Re-d. Q. 152. Also, as to a variety of ways of running and connecting electrical conductors; I mean, broadly, the manipulation of electric conductors?

A. Yes.

Re-d. Q. 153. Calling your attention to Edison's Exhibits 8, 10 and 11, and to the fact that they are entitled "electric tramways," and show an electric locomotive mounted upon rails, would it, in your judgment, require anything more than the effort of electrical skill to provide the mechanical appliances which are wanting in those sketches, to make the locomotive operative?

> Counsel for Siemens objects to the question as suggestive, and also, that the witness, on account of the business relations existing between him and Mr. Edison, is not qualified to testify as an expert in this case.

A. No.

Re-d. Q. 154. State whether or not, in the answers to the cross-interrogatories before referred to, you understood such interrogatories to be limited to

the precise construction shown in the exhibits inquired about, and answered accordingly?

A. In the answers referred to, my remarks I intended to be the strict and close interpretation of the drawings in Exhibits 8, 10 and 11.

CHAS. L. CLARKE.

STATE OF NEW YORK,
City and County of New York, } SS.:

I, WILLIAM H. MEADOWCROFT, a Notary Public within and for the City and County of New York and State of New York, do hereby certify that the foregoing depositions of Julius F. Hornig, John Kruesi, Thomas A. Edison, Francis R. Upton, John Ott, C. L. Dean, G. F. Barker, C. T. Hughes, and Charles L Clarke were taken on behalf of Thomas A. Edison, in pursuance of the notices hereunto annexed before me at No. 65 Fifth avenue, in the City of New York, on the 16th, 17th, 18th, 21st, 22d, 23d, and 25th days of November, and the 7th, 8th, 9th, 10th, and 12th days of December, 1881; that each of the said witnesses was by me duly sworn before the commencement of his testimony; that the testimony of the said witnesses was, by consent of all parties, written out by Henry W. Seely; that C. S. Whitman, representing the opposing party, Siemens, and Messrs. F. W. Whitridge and William D. Baldwin, representing the opposing party, Field, were present during the taking of said testimony; that the taking of said testimony was commenced at the time and place designated in said notices, and was concluded on the 12th day of December, 1881; and that I am not connected by blood or marriage with any of the said parties, nor interested, directly or indirectly, in the matter in controversy.

In testimony whereof I have hereto set my hand and official seal at said City of New York this 13th day of December, A. D. 1881.

[SEAL] WM. H. MEADOWCROFT,
Notary Public,
New York County.

1

IN THE U. S. PATENT OFFICE.

KEITH
vs.
EDISON.
vs.
BRUSH.
} Interference Dynamo Electric Machines. 2

TO MESSRS. LEGGETT & LEGGETT, Attorneys for Brush:

Take notice that on Saturday, October 15th, 1881, at ten o'clock A. M., at No. 65 Fifth avenue, we will proceed to take the testimony of Thomas A Edison, John Kruesi, Francis Jehl, Charles Clarke, Francis R. Upton, John Ott and others, in behalf of said Edison, and continue the examination from day to day until completed. 3

DYER & WILBER,
For T. A. Edison.

Service acknowledged.
LEGGETT & LEGGETT, 4
Attorneys for Brush.

5 IN THE U. S. PATENT OFFICE.

KEITH
vs.
EDISON.
vs.
BRUSH.

Interference Dynamo Electric Machines.

6

To S. J. GORDON, Esq., Attorney for Keith:

Take notice that on Saturday, October 15th, 1881, at ten o'clock A. M., at No. 65 Fifth avenue, New York City, we will proceed to take the testimony of Thomas A. Edison, John Kruesi, Francis Jehl, Charles Clarke, Francis R. Upton, John Ott and others, in behalf of said Edison, and continue the
7 examination from day to day until completed.

DYER & WILBER,
For T. A. Edison.

Service acknowledged October 11th, 1881.

S. J. GORDON.

IN THE U. S. PATENT OFFICE.

8 KEITH
vs.
EDISON.
vs.
BRUSH.

Interference Dynamo Electric Machines.

In pursuance of the annexed notices the parties to the above interference attended before me on the

day therein named, either in person or by attorney, 9
as follows:

Nathaniel S. Keith, in person.

Thomas A. Edison, by Geo. W. Dyer, his counsel.

Charles F. Brush, by L. L. Leggett and H. A. Seymour, counsel.

S. J. Gordon, counsel for Keith, not being present, it was stipulated that his right to object to questions on behalf of Keith should be reserved.

The testimony was, by consent of the parties, reduced to writing by Henry W. Seely, who was first 10
duly sworn to record the same faithfully.

WM. H. MEADOWCROFT,
Notary Public,
N. Y. County.

THOMAS A. EDISON, a witness produced in his own behalf, being duly sworn, testifies as follows, in answer to questions proposed to him by George W. Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and 11
occupation.

A. Thomas A. Edison; residence, Menlo Park, N. J.; age, thirty-four; occupation, inventor.

Q. 2. When did you first conceive of the idea of regulating the active force of a magnet by interposing a resistance in its circuit or by varying the current by means of a shunt containing an adjustable resistance?

Question objected to on the ground that the
question calls for testimony relating to sub- 12
ject matter in nowise constituting the issue in this interference.

A. I think I conceived this some time in 1872, but I find it reduced to practice in a patent, No. 160,405, filed July 29, 1873.

Q. 3. Is this conception, referred to in the previous question, embraced in patents which have been issued to you, and if so, in what patents and when were the applications filed on which these patents were based?

Same objection as to previous question.

13 A. Embraced in Patent 147,917, filed July 27th, 1873; 219,393, filed July 10th, 1879; 195,751, filed January 27th, 1875; Patent 168,385, filed January 26th, 1875; Patent 186, 330, filed May 16th, 1876.

Notice is given that copies of the above patents will be put in evidence before this testimony is closed. Meanwhile a bound volume containing the patents in question is tendered for examination.

14 Q 4. Please to explain briefly wherein the invention referred to in the previous answer is found in these patents respectively.

Objected to as immaterial and incompetent for the reasons before given.

A. In Patent 147,917, the strength of a magnet *m*, through which there is a constant current passing, has its magnetism varied by means of an adjustable resistance *n*. In Patent No. 219,393, a
15 shunt circuit round the field magnet of a dynamo is shown, whereby its strength can be varied. In Patent 195,751, the strength of a magnet in the line is varied by an adjustable resistance placed in a shunt around it. In Patent 168,385, a constant field magnet has its strength regulated by an adjustable resistance placed in a circuit containing a constant current. In Patent 186,330, a constant field magnet, made magnetic by a helix through which a current passes constantly, the strength of
16 the field magnet being varied by an adjustable resistance placed in the constant circuit. In my answer to question 3, I left out Patent 160,405, upon which the application was filed July 29th, 1873. This patent shows an adjustable rheostat placed in a shunt around an electro magnet, for varying the strength of the same.

Q. 5. Referring to Patent No. 160,405, just mentioned by you, was the invention therein described put by you in actual use, and if so, to what extent?

Same objection as before.

A. Yes, sir; it was put by me in actual use on 17
the Automatic Telegraph Company's lines, between New York and Washington, about July, 1873. I think several of them were used on the line. I have used the same apparatus constantly for different purposes since 1873, as the patent's name will show, in the manner shown by the patents and in various other ways not shown by the patents.

Q. 6. Please examine Patent No. 224,511, granted to C. P. Brush, February 17th, 1880, being the
patent involved in this interference, and state 18
whether you understand the same?

A. My impression is that I do understand it. In fact I am quite sure I understand it.

Q. 7. Comparing the said Patent 224,511, with your Patent 160, 405, what essential difference is there, if any, in the two inventions.

A. There seems to be no difference to me in the inventions. The purposes for which the inventions are to be used, or rather the connections in which
they are to be used, are different. But the inven- 19
tion is the same.

Q. 8. Could the connections with the electro-magnet, employed by you in Patent No. 160,405, be equally well employed, and with the same effect with a dynamo machine of the character shown in Patent 224,511.

Objected to as incompetent and immaterial.

A. All that would be necessary would be to rotate 20
an induction bobbin between the poles of the magnet shown in Patent 160,405, and connect one end of the wire from the induction bobbin to the wire marked *f* on the left hand side in Patent 160,405. The other end of the wire from the induction bobbin and the wire marked *f* on the right hand side would form the poles.

Q. 9. When was it that you made the application of the same principle referred to in your previous

21 answer to the magnets of a dynamo or magneto-electric generator.

> Objected to on the ground that thus far it has not been shown that he has ever applied the principle set forth in any of the patents to which he has referred to a magneto or dynamo-electric machine.

A. In patent 186,330 the figure on the right hand top of the drawings of that patent shows an ap-
22 paratus which in that connection is used as a motor, but which can be either used as a magneto machine or a motor without change of construction, as is proved by my subsequent patent 218,166. In this mechanism shown in patent 186,330 there is a field magnet in the form of a vibrating iron core, which iron core is surrounded by a helix of wire through which a constant current from a battery, n^2, circulates, and within this circuit is included an adjustable resistance whereby the strength of the
23 current exciting the field of force helix may be varied. This apparatus is fully described and set forth in the specification. In October, 1878, I varied the strength of the field of force magnets by an adjustable resistance which was in the circuit of the field magnet and not in a shunt around the same. Some time in February, 1879, I varied the strength of a field magnet in a dynamo machine by varying the resistance of a shunt around the field magnet as is shown in my patent 219,393.

24 Q. 10. Referring now to the issues set up by the Patent Office in this interference, to wit: "first a dynamo-electric machine constructed or combined with suitable devices for primarily varying the strength of the current exciting its field of force electro-magnets."

Second. "In a dynamo electric machine, the combination with one or more of its inducing or field of force electro-magnets of an adjustable resistance whereby the strength of the current applied to said magnets may be determined and gov-

erned and varied." When did you make the inven- 25
tion thus described in these issues?

A. The application of this principle to a dynamo electric machine is shown as I have already stated in my patent 186,330. In October, 1878, I used a dynamo electric machine combined with a resistance for primarily varying the current of the field of force magnets, which resistance was adjustable for governing the strength of said magnets. This machine which I used was known as the Wallace
machine, which was brought into my laboratory 26
some time in September, 1878, which machine was used by me for experimenting on incandescent lamps. Since that date I have continuously used dynamo electric machines of various kinds without intermission, in which the strength of the field of force magnets was varied by means of an adjustable resistance, and I do not remember more than one or two occasions where I used dynamo machines in which this variable resistance was not used. In fact
the nature of the lamp which I have been experi- 27
menting on since 1878, is such that I could not have used a dynamo machine, except I used devices for regulating the strength of the field of force magnets; and I have in my various applications and caveats spoken of the fact that I use a constant or separate circuit for exciting the field of force magnets, but I never made a claim to the use of an adjustable resistance in the circuits of such field magnets until my attention was called to the fact by Major Wil-
bur, in the latter part of 1879, that this might be 28
patentable. In my patent No. 227,228, filed February 3d, 1879, paragraph 55, I speak of a constant field of force magnet; also in my patent 227,229, filed April 21st, 1879, paragraph 40, I speak of a constant electro magnet. I also speak of a separately energized field of force magnet in my patent 222,881, filed September 20th, 1879; also in my patent 219,393; I also speak of various devices and means for regulating the strength of a constant field magnet in my caveat filed August 7, 1879; I also speak of a con-

29 stant field magnet in my caveat which was written March 17, 1879. To sum up, I conceived the idea of regulating a magnet by a variable resistance in the shunt circuit around the same in the early part of 1873; I devised an apparatus a short time previous to May 16, 1876, meeting the counts in this interference, which apparatus was made and used and worked at my laboratory at Menlo Park, and on the lines of the Western Union Telegraph Company, at New York, 30 and it operated perfectly, and I used the same between the date given and October, 1878; at various times intermittently, and after October, 1878, continuously, up to the present time; the same having been on public exhibition in my laboratory since October, 1878.

All that portion of the answer is objected to which pretends to carry the date of the conception, or the reduction to practice of the 31 invention in issue prior to September, 1878, as ante-dating the preliminary statement. That portion of the answer relating to the embodiment of this invention in the Wallace machine, is objected to on the ground that the absence of this machine has not been accounted for. If in existence, it is the best evidence of the facts alleged, and should be produced and filed as an exhibit. Further, all that portion of the answer relating to caveats is objected to 32 in the absence of copies of said caveats, as they are the best evidence of the facts alleged, and should have been produced and filed in evidence.

Counsel for Edison gives notice that the caveats referred to being in the custody of the Patent Office, cannot be produced here at this time, but will be produced at the hearing. Meanwhile, authentic copies of the same are tendered for the counsel for Brush to examine into.

Q. 11. In your previous answer you say: "I de- 33 vised an apparatus a short time previous to May 16, 1876, meeting the counts in this interference." Please state whether or not such apparatus was embraced in a patent, and if so, give the number of it?

Objected to as calling for testimony antedating the preliminary statement.

A. Yes, sir; it was embraced in a patent, No. 186,330, and is there used as a motor. I have ex- 34 plained the operation of this apparatus in a previous answer.

Q. 12. Was the Wallace machine about which you have testified as used Menlo Park in September, 1878, a dynamo electric machine?

A. Yes, sir.

Q. 13. Do you know where that machine is now? If so, state where?

A. I had two machines; one a large one, and one a smaller one, both of which were used in the man- 35 ner I have stated. The smaller one was returned to Mr. Wallace some time in the early part of 1879; the other I have still in my possession.

Q. 14. Do you know what became of the resistances and connections which were used with the Wallace machine which was returned?

A. I think I have a great number of them at Menlo Park, and can produce them if desired.

Q. 15. Will you make search for the same, so as to have them here on Monday morning? 36

A. Yes, sir; I will. I also think I have some sketches relating to this matter, and will produce them also.

Q. 16. Where is the Wallace machine which was not returned, which you say you think you have in your possession?

A. It is at my shop at Goerck street, New York. I am willing to offer it for inspection. The machine weighs about a ton and a half, and would be inconvenient to present as an exhibit in this case.

37 Q. 16½. With what other dynamo electri cmachines, if any, did you employ resistance, and their connections in the manner and for the purposes set forth in the issues of this interference, and when and where?

A. I employed it in the magneto machines shown in patent 218,166. I employed it in a Gramme machine in the early part of 1879, and in all of my own machines made since the early part of 1879, at my laboratory at Menlo Park; on the steamship
38 City of Columbia, which was put in May, 1880; in November, 1879, I made a elaborate regulator for regulating the pressure upon my mains at Menlo Park, employing several dynamo machines, lighting up my laboratory and several houses in the vicinity with about 100 incandescent lights; such regulator being made especially that its operation might be explained to the public. Between November, 1879, and February, 1880, more than 20,000 people came to see the exhi-
39 bition, a majority of whom had this explained to them. The regulator which I have spoken of served to regulate the strength of the field of force magnets of the several dynamos employed by me, by the use of a variable resistance thrown in and out of circuit. The necessity of an increase or decrease of the strength of the field of force magnets being indicated by a galvanometer.

> Objection is made to that portion of the answer relating to the regulator, said to have
> 40 been made in November, 1879, as the thing itself should be produced for inspection and introduced in evidence if it is to be relied upon to prove a reduction to practice by the witness.

Q. 17. Upon an examination of your English patents, just made by you, do you find the subject matter of this interference embraced in any one of them, and if so what one, giving the number and date?

A. I find in my British patent, No. 2,402, of the 41
17th of June, 1879, paragraph 30, the following: "The field magnets may be connected in multiple arc and the thermo electric piles arranged in the same manner with appliances whereby the strength of all the fields may be increased or decreased at pleasure, thus increasing or decreasing the electromotive force of the induction bobbin, thus making it easy and convenient by the aid of electrometers at the central station to counteract the rise and fall in the electro-motive force on the main conductors 42
when the maximum and minimum number of lamps may be working." In paragraph 35 is the following: "I will mention that the electro-motive force of the machine is analogous to the pressure in the system of gas lighting, and at dusk, when the lamps are being rapidly connected to the circuit, the electrometer will show a slight drop in the electro-motive force or pressure, and this may be increased by increasing the speed of the prime mover, or increasing the power of the field mag- 43
nets. The latter method is the one I prefer."

I find in my British patent, No. 5,306, dated December 28th, 1878, the following, commencing at line 5: "The electric generators at the central station are provided with constant field of force magnets."

I find in British patent No. 33, of January 3d, 1880, that nearly the whole of the patent relates to the regulation of pressure in a system of electric lighting by varying the strength of the field of 44
force magnets. Also in my British patent No. 302 of the 11th of February, 1880. The patent illustrates methods of regulating the pressure in a system of electric lighting by varying the strength of the field magnets.

> Counsel for Edison gives notice that copies of the English patents referred to are tendered for examination, and copies in the bound volumes of the Patent Office library will be tendered at the hearing.

45 Q. 18. Have you in your possession the magneto
electric machine referred to in a previous answer,
made according to the specification of patent 218,-
166, and having regulating devices as explained by
you?

A. I don't know whether I can find the machine.
I will try. The regulator which I spoke of in the
answer referred to, I will produce when required,
as also the regulators used by me in 1878 and
'79.

46 Counsel for Brush requests that this regulator be produced and filed as an exhibit.

Q. 19. What kind of resistances did you use in 1878 with your dynamo electric machines, and what kind have you used since?

Objected to in so far as it calls for anything prior to September, 1878, the date set up in the preliminary statement.

47 A. I here produce a sketch and order and de-
scription which I find in my shop order book, dated
March 4th, 1879, in the handwriting of Mr. Batch-
elor, one of my assistants, and March 19th, 1879, by
"J. K.," meaning John Kruesi, the foreman of the
shop. Around this bobbin of wood was wound
naked copper wire, so that it would radiate the heat
generated by the current, by permitting air to cir-
culate all around the bare wire. The two ends of
these wires so wound around this block were con-
48 nected to two binding posts on the top and so ar-
ranged that a plug could throw the wire
in and out of circuit. This kind of coil
was used from September, 1878, up to the present
time, for regulating the strength of the field of
force magnets of a dynamo-electric machine; a
number of these being connected together and
thrown in and out of circuit, either by taking the
plugs in and out of each coil, or they were arranged
and connected to a circular commutator or rheo-
tome, having a movable arm which placed a greater
or less number of coils in the circuit of the field of

force magnet, when the arm was rotated in one or 49
the other direction.

A copy of the sketch and entry in the order-book referred to, is put in evidence and marked "Edison's Exhibit No. 1."

Counsel for Brush objects to the filing of a
copy, and requests that the original sketch,
with its descriptive matter, be introduced,
and that it be not removed from the book in
which it is contained, that the record of this
invention may not be mutilated but presented 50
intact for inspection at the Patent Office.

Counsel for Edison withdraws his notice, and states that he will file instead a photo-lithographic copy of the page containing the entry in question.

Counsel for Brush does not waive his former objection.

Q. 20. Has there been any intermission since Sep-
tember, 1878, in your open and public use of the
invention set up in the issues of this interference. 51

A. No, sir.

Q. 21. Have you, since the earliest date mentioned in the previous question, made many dynamo-electric machines of various sizes, constructed and combined with devices such as are set up in the issues of this interference. If so, please give some statement as to number and size?

A. I have made them; about seventy-five ma-
chines, weighing about a ton; one machine weigh-
ing five tons; one machine weighing nine tons; an- 52
other weighing sixteen tons; and another one weigh-
ing twenty-one tons. All these machines had their
field of force-magnets, varied in strength by means
of adjustable resistances, as set out in the interfer-
ence referred to.

By consent the taking of further testimony was postponed to Monday, October 17th, 1881, at ten o'clock A. M., at same place.

Wm. H. Meadowcroft,
Notary Public,
N. Y. Co.

53 Pursuant to adjournment the taking of testimony was continued on Monday, October 17th, 1881, same parties being present.

Q. 22. Have you read the testimony taken in behalf of Mr. Keith in this interference, and have you also examined his Exhibit No. 1 put in testimony.

A. Yes, sir.

Q. 23. I call your attention to the testimony of William Hochhausen, and particularly to folio 91 of that testimony, and ask you to explain the in-
54 vention therein described.

A. The statement there made is, that the current that was shunted from the magnet was not wasted, but that it did work in a detinning solution. Now from this I infer, in fact if the statement is correct, there must have been a detinning bath interpolated in the circuit of the shunt, otherwise the current shunted would be wasted. On the other hand the putting in of the shunt actually reduced the current in the main detinning bath. If the
55 shunt was as in the Exhibit No. 1, the current which was shunted could not be otherwise than wasted by being radiated from the shunt in the form of heat. Hence, if the statement is correct that the current which was shunted was not wasted, there must have been a tinning bath in the circuit of the shunt.

Q. 24. Since testifying on Saturday, have you made a further examination of your caveat papers with a view of determining whether or not the sub-
56 ject matter of this interference is included in any of them; and if so, in what caveats and when were they filed?

A. Yes, sir; I have made an examination. I find in my caveat No. 94, dated December 26th, 1879, devices are described which cover the issues in this interference. I find in this caveat the following language: "For energizing the field magnets of the subsidiary generators I use a dynamo-electric machine, the current from which passes through the field magnets of all the subsidiary generators either

in series or in multiple arc. In this circuit I place a 57
large number of resistance coils of large wire, and subdivided so that each has, say one-fiftieth of an ohm resistance. A wire between each resistance coil leads to a rotary commutator, which, by being turned, short circuits a greater or less number of the resistance coils, thus increasing or decreasing the strength of the current in the field magnets of the subsidiary generators. This, in its turn, increases or decreases the strength of the current in the induction bobbins between them, and this cur- 58
rent, in its turn, increases or decreases the strength of the field magnets in the main line generators, and cause a rise or fall in the pressure or electro-motive force of the line currents, according as more or less energy is drawn from the station by putting on or taking off more or less lamps or electric engines. Thus I am enabled to cause a rise or fall in the electro-motive force by turning of the commutator. To indicate the rise or fall of electro-motive force, the operator at the commutator has before him the elec- 59
tro-dynamometer, as well as several standard lamps, to indicate the rise and fall."

Counsel for Edison gives notice that the original caveat referred to in the previous answer will be produced at the hearing, and a copy of the same is now tendered for examination.

Q. 25. Since your examination of Saturday have you found exhibits bearing upon the issues of this 60
interference. If so, produce them, with explanations?

A. Yes, sir. I have found some exhibits which I now produce. The coils of wire which I now produce were used by me about February, 1879, and were placed in the circuit of the field magnet of a dynamo-electric machine, to regulate the strength of the current passing through the same. The rheotome, with movable handle, the rods, and index wheel formed the regulating

61 mechanism spoken of by me in my testimony as
being put up in November, '79, for the purpose of
giving an exhibition. The buttons or contact points
of the rheotome were connected to a series of re-
sistance coils similar to the coils which I make my
exhibit. The rheotome was placed in the second
story and the handle of the rheotome was connected
by a rod to a table in the first story where the gal
vanometer indicating the electric pressure upon the
system was placed. Placing the coils of wire in
62 one story and means for indicating the pressure in
another story was for the purpose of preventing
any action on the galvanometer of the current which
passed through the coils. The coils and this rheo-
tome were interpolated in the circuit of the field of
force magnets and a greater or lesser number of
coils could be thrown in the circuit by moving the
arm of the rheotome, thus varying the strength of
the current in the consumption circuit to meet
various conditions. This apparatus was, as I have
63 already testified, actually used and exhibited and
explained to many thousand people within a couple
of months after being put in operation. It contin-
ued in operation through all my exhibitions, and
has only recently been taken down and disconnected
from the machine to make changes in the labora-
tory. In September, 1878, magnet coils and
stretched wire were used to regulate the strength
of the field of force magnets, but the stretched wire
by being heated expanded out of shape and the
64 magnets being frequently burnt up, the resistances
as shown in my exhibit were afterwards made.
Since February, '79, all resistances for regulating
the field have been made in the way shown in this
exhibit, and are now furnished with each machine
sold to the public, together with a rheotome similar
to the rheotome shown in the exhibit.

The resistance coils spoken of in the pre-
ceding answer are put in testimony and
marked Edison's Exhibits, Nos. 2, 3 and 4.

Q. 26. When you used these resistance coils, Ex- 65
hibits 2, 3 and 4, in February, 1879, were any
devices used for varying the resistance, and if so,
what?

A. Yes, sir; several coils were placed in
a circuit, and the total resistance was varied by
plugging in or out one or more coils, provision be-
ing made on the top of each coil for performing that
operation.

Q. 27. Since February, 1879, have these Exhibits
Nos. 2, 3 and 4 been used continuously at Menlo
Park, with a dynamo-electric machine, in the man- 66
ner and for the purposes stated in the issues of this
interference?

A. Yes, sir; they have been used continuously
up to about six months ago, when I left the labora-
tory and came to New York, where some of similar
construction are used and sold to the public in the
connection and for the purpose of which I have al-
ready testified.

Q. 28. When were these Exhibits, 2, 3 and 4. 67
disconnected from the machine for the purpose of
making repairs in the laboratory?

A. I think it was in July or August, 1881, al-
though I am not certain of these dates. It might
have been later; certainly not earlier. The coils
which form my Exhibits 2, 3 and 4, are only a few
of those which I have of the same general kind.

Q. 29. What method or plan did you adopt for
varying the resistance next after using the plugging
system? 68

A. The use of a rheotome for throwing in and
out the coils.

The rheotome referred to is put in evidence
and marked "Edison's Exhibit, No. 5." The
connecting rods marked "Edison's Exhibit,
No. 6," and the plate for holding the con-
necting rods "Edison's Exhibit, No. 7."

Q. 30. I understand that this particular rheotome,
marked Edison's Exhibit, No. 5, was first put in

69 use in November, 1879. How long did the use of this particular rheotome continue?

A. My impression is that it was put in use previous to November, 1879. I think as far back as June or July, 1879, but it was not put up in the manner I have described, so that its operation could be made clear to the public, until November, 1879. As to the length of use of this particular rheotome, that is embraced in a former answer.

Q. 31. Since that date, namely, June or July,
70 1879, of this kind of rheotome, have you made and used and sold substantially the same device with dynamo electric machines.

A. Yes, sir, rheotomes and resistance coils substantially like the exhibits.

> Counsel for Edison here rests his examination of this witness and offers him for cross-examination.

Cross-examination by H. A. Seymour, Esq., of
71 Counsel for Brush.

x-Q. 32. What is the prime object of the invention in issue.

A. The letter from the Patent office defining the object is the best evidence of that. I understand that.

x-Q. 33. I do not desire your opinion on a question of law, but desire your understanding of the prime object of the invention in issue.

A. My understanding of the points in issue is a
72 dynamo electric machine or magneto electric machine or electro motor of any kind or character having the strength of the constant field of force varied by regulating the strength of the current circulating through a magnet; and my further understanding is the use of an adjustable resistance to vary the strength of a magnet making a constant field either in a motor or a dynamo or magneto electric machine.

x-Q. 34. Is not the prime object of the invention in issue to primarily vary, regulate or adjust the

strength of the main current generated by one or a 73
battery of magneto or electro dynamic machines.

A. Yes, but as these electro dynamic or magneto electric machines are convertible engines, and can be used either for generating currents or act as motors to perform work and utilize current, the points at issue cover motors as well.

x-Q. 35. For present purposes we will allow the office to determine the scope of the issues in this interference. I now desire to know simply this; is
not the prime object of the invention in issue to 74
primarily vary the strength of the main current generated by one or a battery of magneto or dynamo electric machines.

> The question is objected to for the reason that the Patent Office having defined the issues in controversy, all inquiry outside of those issues becomes incompetent, and the issue does not say anything about a battery of magneto or dynamo-electric machines.
>
> Counsel for Brush would suggest that if 75
> any question is competent, certainly the question calling for an explanation of the object to be attained by the improvement which the witness alleges he has invented, is a competent question, for if anybody knows what that object is, the witness must.

A. If it is desired to know what my object was, I will state that it was as is stated by the Patent
Office in defining the issues of this interference, and 76
extended to dynamo machines, when used as electro-motors.

x-Q. 36. What is the object of varying the strength of the field of force magnets of a dynamo machine?

A. My object is to keep the pressure or electromotive force constant in the main circuit.

x-Q. 37. Irrespective of the work it has to do?

A. Yes, sir.

x-Q. 38. Then the prime object of the invention

77 disclosed in your application in this interference is to primarily vary, adjust or regulate the strength of the main current generated by the dynamo-electric machines, is it not?

A. In my application in controversy the system of using lamps in multiple arc is the one used. The number of lamps in circuit determines the strength of the current, and the object of regulating the strength of the field so that whatever current is caused to circulate by addition or subtraction of
78 lamps, that it should have the same electro-motive force.

x-Q. 39. By varying the strength of the field of force magnets, you attain one result, do you not, which is to primarily vary or regulate the strength of the main current?

A. To primarily vary the strength of the main current it would be necessary to have the resistance in the main circuit. By means of a resistance you primarily vary the strength of the current passing
79 through the field, and this indirectly varies the electro motive force in the main circuit.

Q. 40. If the resistance were placed in the main circuit would it operate to vary the strength of the current generated by the machine; or would it simply consume or waste a portion of the current generated, thus lessening the strength of the current in the main circuit, without changing the strength of current generated.

A. If the resistance was placed in the main cir-
80 cuit and the field of force magnets were not connected with the main circuit, but had a constant field, the effect would be to weaken the current while the electro-motive force of the machine would remain constant. A portion of the current, or rather energy, would be lost on the resistance coils, and so there would be energy lost as well on the resistance coils placed in the field of force magnet circuit.

x-Q. 41. The capacity of a dynamo machine is regulated or may be primarily varied by varying the strength of its field of force magnets, and is so done

in the improvement disclosed in your application, is 81
it not?

A. Yes.

x-Q. 42. And the object to be obtained in your application in interference by varying the strength of the field of force magnets is to primarily vary, regulate or adjust the strength of the main current, is it not?

A. Yes, in one sense it is.

x-Q. 43. In Letters Patent No. 160,405, granted
to you March 2d, 1875, do you therein find any 82
statement or suggestion relative to the varying, or adjusting or regulating the strength of the main current; was this the object of the invention disclosed in the said patent?

A. I find in that patent that an electro-magnet had a shunt circuit placed around it containing a variable resistance for primarily regulating the strength of the current passing through the magnet and as both the shunt and the magnet formed part
of the main telegraphic circuit, an increase or de- 83
crease in the resistance of the shunt and magnet would necessarily produce an increase or decrease in the strength of the current on the main line.

x-Q. 44. What I wish to know is this, do you find in Letters Patent No. 160,405, any hint or suggestion that the object of the invention was to primarily vary the strength of the main current?

A. The object was to vary the strength of the main current within the magnet; but the object for
which the invention is to be used does not alter the 84
invention.

x-Q. 45. Prior to the invention shown in patent 160,405, instead of regulating the attractive force of the electro-magnet as described in said patent, it had long been the custom to regulate the force of the retroctile spring connected with the armature, had it not?

A. Yes, sir, I believe it had.

x-Q. 46. Prior to the date of this invention, and long prior, it had been customary to regulate the

85 strength of an electro magnet by means of a variable resistance located in a shunt around the magnet, had it not?

A. The Patent Office gave no reference on that subject when the patent was granted, and I know of no instance previous to that patent.

x-Q. 47. In duplex systems of telegraphy, patented long prior to the date of patent 160,405, were not variable resistances employed in a shunt around the receiving instrument, the latter provided with
86 electro-magnets and affected as desired by the variable resistance in the shunt.

A. I do not call to attention any cases of this kind except in some of my duplex inventions in 1873, where a resistance was shunted around an electro-magnet of a compound character, not a simple electro-magnet; in all duplexes which I now call to mind the resistance was in the same circuit with the magnet; I have not all the duplex patents by me.

x-Q. 48. I now read you the third claim of reis-
87 sued Letters Patent No. 5,181, dated December 10, 1872, original patent No. 26,097, granted to Moses G. Farmer, November 15th, 1849. This claim reads as follows, "The combination of a rheostat or adjustable shunt with a receiving instrument so arranged that any desired portion of the current upon the main line wire can be allowed to pass through the receiving instrument." I desire that you shall carefully examine this patent, particularly with reference to the invention referred to in said third claim,
88 and then state if you are still of the opinion that you are the first to conceive the idea or principle of "regulating the active force of a magnet by interposing a resistance in the current or by varying a current by means of a shunt containing an adjustable resistance," as specified in question 2 of your direct examination.

A. I have examined the patent and find that the two inventions are not similar; in the patent of Farmer, the device shown contains two coils of wire forming together an electro-magnet, one of which

serves to shunt a portion of the current from one of 89
the sections of the electro-magnet, while it does not affect the other sections of the electro-magnet; the rheostat of Farmer might be so adjusted that while a strong current was passing through the electro-magnet, the iron would have no magnetism, but this is not possible with my invention, and he states in his specification that the object of his device is to obviate the defect of not having both coils properly proportioned, one with the other; it is in fact a differential magnet, and to obtain a perfect balance 90
and render the magnet operative, the shunt is used upon a portion of the wire around the magnet.

x-Q. 49. Is not the active force of the electro-magnet in Farmer's receiving instrument varied, regulated or adjusted by means of a variable resistance placed in a shunt circuit?

A. Not directly, but indirectly, and by a different means.

x-Q. 50. It was old, then, was it not, long prior to your invention to regulate the active force of a 91
magnet by a variable resistance located in a shunt circuit?

A. Not directly.

x-Q. 51. Not directly what—old?

A. It was old to regulate it indirectly, but not old to regulate it directly, as in my invention; in the case of Farmer's invention, the action of the rheostat upon the compound magnet would be the opposite of its action when applied to the simple magnet shown in my patent, for, when he adjusted it to 92
accomplish the object which he desired, any change in the resistance of the rheostat, whether its resistance was diminished or increased, would strengthen the electro-magnet, and this is not so in my invention, shown in patent 160,405, in which an increase of the resistance of the shunt will strengthen the magnet, and a decrease in the resistance of the shunt will weaken the magnet.

x-Q. 52. I have not asked you to point out the particular differences of construction and operation

93 existing between Farmer's 1859 patent and yours, No. 160,405, but I desire to know this, does not the Farmer patent show that, broadly speaking, "the idea of regulating the active force of a magnet by interposing a resistance in the current, or by varying the current by means of a shunt containing an adjustable resistance;" was old long prior to your invention.

A. The use of a shunt around one coil of a differential magnet, I think, was known many years
49 previous to 1859; it was the common method of evening up the dissimilarity between the two coils in galvanometers; but I know of no instance where the strength of the iron core of a simple electro-magnet was varied by means of an adjustable shunt placed around a single helix of wire, covering the iron core, except in my patent aforesaid.

x-Q. 53. Question repeated.

A. I can make no other answer.

x-Q. 54. I now read a paragraph from the Farmer
95 patent, wherein he acknowledges the state of the art as it existed prior to 1859: "In Figure 3 I have represented the rudiments of a previously known plan for transmitting two messages simultaneously; when the key, K, is depressed, the current from the battery, B, splits or forks at the point, U, and half goes through the helix, 1, on one leg of the magnet, and half through the helix, 2, on the other leg of the magnet, the two half currents neutralizing each the effect of the other, and
96 the relative strength of the two halves being adjusted by the rheostat, R;" I desire that you examine Figure 3, in connection with this paragraph, and state if you are still of the opinion that you are the first to invent the principle or "the idea of regulating the active force of a magnet by interposing a resistance in the current, or by varying the current by means of a shunt containing an adjustable resistance."

A. Yes, sir; I believe I am. In Figure 3, the resistence is not in the shunt, but in the same line

with the wire around the leg 2 of the magnet. By 97
carefully reading your question, I see that you desire me to answer, regarding the regulation of the strength of a magnet placed in the same circuit as the coils of the magnet and not as a shunt around the coils. So placing the resistance in the same circuit with the coils of the magnet, I believe to be even older than the Farmer patent.

By consent, the taking of further testimony was postponed to ten o'clock Tuesday
morning, October 18, 1881. 98

WM. H. MEADOWCROFT,
Notary Public,
N. Y. Co.

Pursuant to adjournment, the taking of testimony was continued on Tuesday, October 18th, 1881, at 10 o'clock A. M., same parties being present.

x-Q. 55. Then it is true that the "idea of regu-
lating the active force of a magnet by interposing a 99
resistance in the current" was old and well known long prior to your invention, is it not?

A. Placing a resistance in a circuit in which there is a magnet, I believe was done long prior to my invention.

x-Q. 56. It was done for what purpose?

A. For various purposes.

x-Q 57. For regulating the active force of a magnet, among others?

A. I do not call to mind when the resistance was 100
intended to regulate the active force of a magnet when the same was placed in the same circuit as the magnet, but the resistance was manipulated to accomplish other objects.

x-Q 58. In the use of the resistance indicated in that portion of the Parmer patent last referred to, does not the resistance affect the magnet to prevent the receiving instrument being actuated by the sending current?

101 A. That is the object.
x-Q. 59. In patent 160,405, I find the following
statement: "I do not claim a rheostat or adjust-
able resistance in a shunt circuit to regulate the
current passing through a chemical receiving in-
strument. I do not claim a shunt around an
electro-magnet with a resistance that is not variable
and serves to lessen the injury to the contact
points." Was this disclaimer made because of any
of your prior applications covering that subject
102 matter, or because such inventions were old ?

A. I don't remember.

x-Q. 60. Please give us your best impressions in
this matter.

A. I have no impressions; it is so long ago.

> Counsel for Brush here puts in evidence a
> printed copy of reissued Letters Patent No.
> 5,181, dated December 10th, 1872, and desig-
> nates the same as "Brush Exhibit Farmer
> Reissue."

103 It is hereby stipulated by and between
counsel that printed copies of patents put in
evidence by either party, may be used as evi-
dence with the same force and effect as if
certified.

x-Q. 61. Please examine Letters Patent 123,711
granted to George Little, February 13th, 1872, and
state whether or not it shows "a rheostat or ad-
justable resistance in a shunt circuit to regulate the
104 current passing through a chemical receiving instru-
ment."

A. It does. Since my attention has been called
to this question of yours I have examined my
patents and I have refreshed my memory, and find
that I used a variable shunt around a chemical in-
strument some time in 1870. I have a patent, No.
114,656, which refreshed my memory on this subject.

x-Q. 62. But this patent No. 114,656 shows no
adjustable resistance, does it?

A. It only serves to refresh my memory. In

patent 134,867 an adjustable resistance is shown. 105
also patent 141,772 shows a shunt circuit with an
adjustable resistance attached. In patent 147,311 is
shown a shunt round a chemical instrument and
also round a plain electro-magnet. In this case the
electro-magnet is not used as a motor, but to give
induction currents whose strength relative to the
chemical instrument is varied by a rheostat. This
is more clearly set forth in my patent 147,317 in
which a constant magnetic field is regulated by
cutting in and out of circuit more or less coils around 106
the iron cores of the magnets.

> Counsel for Brush introduces in evidence
> copy of patent 123,711 granted to George Lit-
> tle, February 13th, 1872, and designates it
> "Brush Exhibit 1."

x-Q. 63. Please look at patent No. 82,695, dated
October 6th, 1868, granted to S. F. Day, and state
whether or not it shows a resistance in a circuit for
varying the active force of a magnet ? 107

A. No, sir, it does not, if I understand it right.
There is a constant resistance, and the relay serves
to close a sounder around it. It is the action of the
relay which varies the magnetism of the sounder.

> Counsel for Brush introduces in evidence
> copy of Letters Patent 82,695, granted to S.
> F. Day, October 6th, 1868, and designates the
> same "Brush Exhibit Day Patent."

x-Q. 64. Please look at Letters Patent No. 130,426, 108
granted to C. H. Haskins, August 13th, 1872,
wherein is found the following statement:
"J is a common rheostat or series of resistance
coils connected to a switch lever in the local circuit
Y, so that the resistance of said circuit may be grad-
uated if occasion demands, as in case the local cur-
rent is found to act too powerfully as compared to
the main circuit, under all circumstances or varying
circumstances," and state whether or not you find
an electro-magnet located in a circuit provided with

109 a variable resistance for regulating the active force of the magnet?

A. I find that the device in the patent set forth is a compound device, the electro-magnet having two bobbins upon it, one portion of the magnet being in the main circuit, the other portion in the local circuit, and that variations in the magnet are brought about by opening the main circuit; that were there no extra circuit, the device would be inoperative to perform the functions set forth in the
110 patent. In my patent 128,605 of July 2d, 1872, a constant was obtained in two electro-magnets for polarizing them in the same manner set forth in the patent of Mr. Haskins, and in using this instrument, resistance coils were used in this constant circuit to attain a balance between the main circuit and the constant circuit. I find in the patent of Mr. Haskins an adjustable resistance for regulating the activity of a compound magnet containing two coils placed in separate circuits, but I do not find an
111 adjustable resistance for adjusting the strength of a simple magnet.

> Counsel for Brush objects to that portion of the answer relating to the patent of witness as being irresponsive, needlessly prolonging the cross-examination and proper subject to be brought out if desired in re-direct testimony.

x-Q. 65. In the Haskins patent in question, you
112 find plainly shown and clearly described, do you not, a simple electro magnet, consisting of the soft iron armature E encircled by the helix D, the latter located in the local circuit in which is placed the adjustable rheostat J for the purpose of varying the strength of the soft iron armature E, in this case constituting the core of the simple electro magnet. Is not this correct?

A. I find an iron core, E, encircled by a helix D, having an armature A A, forming part of that electro-magnet, which armature is again encircled

by two other sets of coils B B and C C, one set of coils C C, being connected in the same circuit with the coil D, in which circuit there is an adjustable resistance, the whole combined to form a compound magnet. 113

x-Q. 66. Do you desire to be understood as holding that a compound magnet located in a circuit provided with an adjustable resistance does not suggest or disclose "the idea of regulating the active force of a magnet by interposing a resistance in the current?" 114

A. It might suggest the idea to some; that would depend upon their impressiveness in receiving suggestions.

> Counsel for Brush introduces in evidence printed copy of Letters Patent, No. 130, 426, granted to C. H. Haskins, August 13th, 1872, and designates the same as "Brush Exhibit Haskins Patent."

x-Q. 67. Please look at Letters Patent, No. 110,-090, granted to B. B. Toye, December 13th, 1870, and state whether or not you therein find an adjustable resistance located in the circuit containing an electro-magnet and constructed and arranged to vary the strength of the magnet at will? 115

A. I find an electro-magnet placed in a main circuit with two wires leading from a portion of said electro-magnet, such wires being connected or disconnected by a switch, but the shunt circuit thus formed has a constant resistance, invariable when the switch is closed and broken when it is open. 116

x-Q. 68. Where a number of coils constitute a resistance and a switch is employed to throw in and out any desired number of the coils, it is a self-evident proposition, is it not, and true in all cases, your own patents inclusive, that the switch being adjusted, the current is constant until the switch is again adjusted, and when the switch is open the circuit is broken?

A. I do not remember any of my applications,

117 where the switch opened the circuit. Where the switch is used to open the circuit it is a very different matter.

x-Q. 69. For once will you please give me a categorical answer; do you find in the Toye patent an adjustable resistance located in the circuit of an electro-magnet for varying the strength of the magnet?

A. No, sir.

> Counsel for Brush introduces in evidence
> 118 copy of Patent No. 110,090, granted to B. B. Toye, December 13th, 1870, and designates it as "Brush Exhibit, Toye Patent."

x-Q. 70. Please examine Letters Patent 142,486, dated September 2d, 1873, granted to G. Little, and state whether you therein find a description of a device adapted to produce the same result in substantially the same way as that shown in your patent 160,405. In connection with
119 the drawings and description I desire to refer you particularly to the following paragraph contained in this patent:

"A rheostat may be employed with connections to the main line at opposite sides of the magnet to cause a division of the current, part passing through the magnet, part through the rheostat and part entering the coil or condenser, and this rheostat may be adjustable or of the required resistance."

A. It is the same as in my patent 160,405, but I
120 desire to state that I practiced that invention before the application of Mr. Little.

x-Q. 71. Was your application filed July 29th, 1873, and on which Letters Patent 160,405 were granted, placed in interference with the application of Little filed October 3d, 1872, and on which his patent 142,486 in question was granted?

A. I don't remember any such interference. I find that my patent 141,772 filed November 9th, 1872, was not placed in interference. It has a device which is somewhat similar.

x-Q. 72. Do you recall the name of the Examiner 121
who allowed your patent 160,405?

A. No, sir.

> Counsel for Brush introduces in evidence printed copy of Letters Patent 142,486, granted the G. Little September 2, 1873, and designates the same "Brush Exhibit No. 2."

x-Q. 73. Please look at Letters Patent No. 33,269, granted to J. E. Smith September 10th, 1861, and state whether or not you therein find a resistance
located in a shunt around an electro-magnet? 122

A. Yes, sir, I do; a constant resistance.

> Counsel for Brush here introduces in evidence copy of Letters Patent No. 33,269, granted to J. E. Smith, September 10th, 1869, and designates it as "Brush Exhibit No. 3."

x-Q. 74. For what purpose was the invention in patent 160,405 used by the Automatic Telegraph Company?

A. It was used in the manner stated in the pat- 123
ent and also for the purpose of preventing induced currents on the magnets from circulating on the line. These magnets were either sounders or had a local circuit connected with them or acted as relays.

x-Q. 75. These instruments were all taken out, were they not, because they were held to infringe the Page patent, and instruments invented by Gerritt Smith substituted for them?

A. No, sir; Gerritt Smith had no connection with 124
the Automatic Telegraph Company until after 1876 or '77.

x-Q. 76. Do you know that one of these instruments is now in use by the Automatic Company?

A. No, sir; I know nothing about it.

x-Q. 77. Do you know that these instruments have not all been replaced by instruments of a different construction and principle of operation?

A. No, sir; I have not been in an Automatic

125 Company's office since 1876; neither do I know what changes they are making in their instruments.

x-Q. 78. Please compare the invention disclosed in patent 160,405 with the invention set forth in your application in interference; are they substantially the same, or substantially different?

A. They are alike in respect to regulating the strength of a plain electro-magnet, but they differ in this: that in the application in interference, the
126 strength of the current passing through the electro-magnet is increased or diminished by adding to or taking from the circuit resistance, while in the patent 160,405, the strength of the magnet is varied by shunting a portion of the current by means of a variable resistance placed around and acting as a shunt to the current passing through the electro-magnet.

x Q. 79. Having described certain differences, I now desire your opinion as to whether or not, the
127 invention shown, described and claimed in your patent 160,405 is substantially the same as, or substantially different from the invention shown, described and claimed in your application in interference?

A. The objects to be attained in both cases are the same primarily; as to whether I have an opinion whether the two inventions are the same or different, I will state that I have no opinion. The point is too complicated to give one off-hand.

128 x-Q. 80. As you seem to have no difficulty in your answer to question No. 7 in comparing the invention shown in patent 160,405 with the Brush patent in interference, I now ask that you will make a like comparison between two of your own cases, to wit: patent 160,405 and your application in interference?

A. There is not the slightest difficulty in regard to the comparison of patent 160,405 with the Brush patent, inasmuch as both are connected, arranged and operated in the same manner, but a comparison

between patent 160,405 and my application in interference is much more difficult for the reason that the devices are applied in a different manner. 129

x-Q. 81. Then you would have it understood, would you, that you have no opinion with reference to the matter enquired of in cross-question 79?

A. I believe I have fully answered cross-question 79.

x-Q. 82. As the matters of construction differ quite radically, among such obvious differences the patent shows a single electro-magnet, and the application a battery of dynamo electric machines, I do not desire you to enter into a detailed description of such differences, but ask your opinion upon this matter, to wit: whether or not in your opinion the invention shown, described and claimed in your patent 160,405 is substantially the same as or substantially different from the invention shown, described and claimed in your application in interference? 130

Counsel for Edison states that inasmuch as the application of Edison referred to in the foregoing question embraces inventions which are not included in this interference he objects to so much of the question as relates to the invention described in such application, and advises Mr. Edison to confine his answer to the issues in controversy as set up by the Patent Office. 131

A. I have fully answered on this point.

x-Q. 83. As there is a difference of opinion on this matter, I will restate the question in a slightly changed form. I desire to know whether in your opinion, the invention shown, described, and claimed in your patent 160,405 is substantially the same as, or substantially different from the invention shown and described and particularly referred to in the second and third clauses of the claims of your application in interference? 132

A. I have already stated the differences between

133 the inventions in patent 160,405 and my application in interference, and I have no opinion whether they are substantially the same or not. Both refer to the same object in a different manner. If the variation in the strength of the magnets were to be produced by combining a shunt around them, as shown in my patent 160,405 and the patent of Mr. Brush, there would not be the same economy in the use of the electric current, as there would be when the variation in the strength of the magnet was
134 made in the manner set forth in my application in interference. If the device shown in patent 160,405 and in the Brush patent in controversy was applied to the electro magnets arranged and operated in the manner set forth in my application in controversy, considerably more power would be wasted than if arranged in the manner set forth in my said application in controversy, and I have the impression of reading somewhere that any combination which effects a saving over that already in
135 use is patentable and constitutes an invention, therefore this point being so abstruse I have not allowed my mind to form an opinion. Besides the patents in controversy are the best source of information.

All that portion of the answer after the words, "I have no opinion whether they are substantially the same or not," objected to as irresponsive to the question.

136 x-Q. 84. Do you find it anywhere indicated in your patent 147,917 that the resistance there employed is an adjustable resistance.

A. Yes, sir; the word "rheostat" is sufficient evidence as to the adjustability of the resistance.

x Q. 85. And where this word is employed in other patents besides your own, it would be sufficient evidence of the fact of an adjustable resistance, would it not.

A. It would, in the absence of any drawings

showing that the device was wrongly named a rheostat. 137

x-Q. 86. In your opinion is the invention shown, described and claimed in your Patent 147,917, substantially the same as or substantially different from the invention shown and particularly referred to in the second and third clauses of the claims of your application in interference?

A. It is true that there is a rheostat for adjusting the strength of a current passing through a magnet, but being a mixed-up combination, like the patents 138
put in by counsel for Brush, I have no opinion upon the subject, except insomuch as a rheostat regulates the strength of an electro magnet.

x-Q. 87. Please state how many dynamo electric machines, constructed in accordance with your patent 219,393, are now in use?

A. I made one complete machine and operated the same. It worked successfully. My impression is I have the machine still. None have been put in use, for the reason that I have something better. 139

x-Q. 88. Does this patent show an adjustable resistance for regulating the strength of the field of force magnets?

A. Yes, sir; it describes, in connection with what it shows, a method of increasing or diminishing the current by adding resistance. The rotating contact cylinder theoretically should shunt the same amount of current away from the field magnets in a given time, whether rotated at twenty-five revolutions a minute or five hundred revolutions a minute. But practically less current is shunted from 140
the field magnets as the speed of revolution of the contact cylinder increases, the resistance of contacts being a function of surface velocity and pressure. It is not a wire resistance, but nevertheless is a resistance variable by speed.

x-Q, 89. Please quote any portion of the specification indicating that the revolving contact cylinder in the shunt around the field of force magnets was

141 intended or is constructed to operate as a variable resistance.

A. I find the following: "I have discovered that an increased magnetic effect is produced in the field of force magnets by periodically shunting the current." Also the following: "The energy of the machine is promoted by shunting the field of force magnets, and this I do every revolution of the shaft *a*, but it may be done more or less frequently."

142 By consent, the taking of further testimony was postponed to Wednesday, October 19th, 1881, at 10 o'clock, at same place.

Wm. H. Meadowcroft,
Notary Public,
N. Y. Co.

Pursuant to adjournment the taking of testimony was continued on Wednesday, October 19th, 1881, the same parties being present.

143 x-Q. 90. In your opinion is the invention shown and described in Letters Patent 219,393, substantially the same as or substantially different from the invention shown, described and referred to in the second and third clauses of the claim of your application in interference?

A. I will not answer that question unless the meaning of the word "substantially" is defined by the counsel for Brush.

144 x-Q. 91. If you are unable to comprehend the meaning of the word "substantially," I will cheerfully re-state the question. In your opinion is the invention shown and described in patent 219,393, substantially the same in construction, adapted to operate in substantially the same manner and produce substantially the same result as the invention shown and described and pointed out in the second and third claims of your application in interference?

A. I object to answering any question where this word "substantially" is used in a general sense.

x-Q. 92. As it is customary for counsel, rather than the witnesses, to interpose objections, I would suggest that that part of these proceedings be left to your counsel. Do you or do you not understand the question? 145

Counsel for Edison states that the witness is willing to describe the construction, manner of operation, purpose and effect of any apparatus properly in question, but believes that a comparison of substantial identity is a matter for the construction of the proper officials of the Patent Office alone. 146

A. I understand imperfectly the question, and will not answer it without the question is made more specific.

x-Q. 93. I will then use the specific language employed in direct question No. 7, comparing said patent 219,393 with your application in interference. What essential difference is there, if any, in the two inventions?

A. I have already answered fully on the question, by describing the operation of the patent in question, and, I believe, pointing out the difference. 147

x Q. 94. Prior to 1878 was it old to excite the field of force magnets of a dynamo machine by a separate dynamo machine?

A. I can't say.

x-Q. 95. Please give us your best impressions whether or not it was old prior to 1878, to excite the field of force magnets of a dynamo machine by a separate dynamo or magneto machine? 148

A. I cannot remember any instance by publication.

x-Q. 96. You are willing to swear then, are you, that you know of no patent or publication prior to 1878, describing a dynamo machine having its field of force magnets excited by a dynamo or magneto machine.

A. I call none to memory that was published.

x-Q. 97. Do you consider the vibrating reed in-

149 strument shown and described in patent 186,330 practically the same as a dynamo machine?

A. No, sir; it is a magneto electric machine. In my patent 218,166 it is arranged as a dynamo machine.

x-Q. 98. When did you first construct a dynamo electric machine.

A. I am unable to answer that question until I have looked over my sketches and drawings.

150 Counsel for Brush desires that the witness investigate his papers or records, and if possible, ascertain the facts inquired of, that he may be able at another time to answer this question.

x-Q. 99. Describe in general terms the construction or type of the first dynamo electric machine you made or had made for you.

A. I have already stated that, without looking over my drawings, I could not give the date of my
151 first dynamo electric machines. I built magneto machines in Boston in 1869, but whether I built dynamo machines I can't remember without refreshing my memory by looking at drawings.

x-Q. 100. Question repeated.

A. I have in my mind that I constructed a certain dynamo machine about a certain time. Whether this was the first one ever constructed by me, I cannot say without refreshing my memory by looking at my drawing. And as the one I have in my
152 mind may not be the first one, I cannot describe it. My impression is that the first dynamo electric machine which I constructed, in the absence of my papers to refresh my memory, is shown in patent 218,166.

x-Q. 101. When, where and by whom was the dynamo machine like patent 218,166 constructed?

A. It was made at Menlo Park by my workmen, I think some time in September, 1878.

x-Q. 102. When and for what purpose was it first 153
used?

A. I think it was used in October or November, 1878, for generating electric currents.

x-Q. 103. For what purpose was the electric current generated by this machine employed?

A. I think the first purpose we used the current for was for agitating the nerves of the tongue.

x-Q. 104. You may recite the schedule of uses to which it was put if you desire, or state simply the practical purposes to which the current generated 154
by this machine was put, as the latter is all that I want to know?

A. The current was used in one case to excite heat in metallic wire, that is to say to heat up a portion of the circuit, which was the practical object to be attained.

x-Q. 105. Was it used for producing electric light?

A. It was used in connection with electric lighting.

x-Q. 106. Was it used as the generator of the 155
main current to produce an electric light?

A. It was used as a generator of current for the purpose of producing an electric light.

x-Q. 107. Were the ends of the circuit containing the electric light—one or more—directly connected with the machine in question when it was used as you state?

A. Yes, sir.

x-Q. 108. For what length of time was this ma- 156
chine thus used?

A. Only a few minutes; the current was to weak to produce the results desired.

x-Q. 109. When did you altogether discard the use of this machine?

A. I laid it aside to adopt a better form.

x-Q. 110. When did you lay it aside?

A. My impression is that I laid it aside sometime in December, '78.

157 x-Q. 111. Please state when you next made a dynamo machine?

A. I desire to state that I do not understand that the question in interference related to the original construction of the dynamo machine; my impression was that the subject matter in interferrence was confined to the combination as set forth in the Patent Office declaration, and hence did not look for data by which to set the date of the construction of this or that form of dynamo machine.
158 I cannot answer without refreshing my memory by looking at my drawings.

> Counsel for Brush requests that the witness will investigate his records during adjournment, that he may be able to give accurate information as to the points inquired of.

x-Q. 112. For present purposes, state the date as near as you can when you made your second
159 dynamo machine?

A. I think the next dynamo machine was constructed in either January or February, 1879.

x-Q. 113. Like which one of your patents was this second machine?

A. It was similar to patent 222,881. If I remember right, there were three different machines constructed about the same time, besides a great many small machines, some being used as dynamo and magneto; one machine was sent on the "Herald"
160 Arctic expedition, connected and worked as a dynamo with arc lights, it being delivered some two or three months before the sailing of the "Jeannette," which, I think, was in the spring or summer of 1879.

x-Q. 114. When and for what purpose was the second dynamo machine of your construction, and used by you, first employed?

A. I don't remember of having used the machines as dynamos except as an experiment. We used them as magnetos, in connection with lighting.

The time when we used them was some time in the spring of 1879. The nature of the lights was such 161
that we could not use dynamo machines but only magneto electric machines, with an electro magnet for making the field.

x-Q. 115. How long did this state of things continue, that is, up to what time were your lights of such a nature that you could not employ dynamo machines?

A. When I say that I could not employ dynamo machines, I mean that class of dynamo machines 162
wherein the whole of the main current passed through the field of force magnets, and up to the present time my lights are of such a nature that I cannot use machines with a great degree of practicability where the whole of the current passes through the exciting field of force magnets, but I have used dynamo machines where the whole of the current passing through the field of force magnets was used, not to work lights, but to energize the coils of other magneto machines as well as its 163
own field.

x-Q. 116. At present I desire information with regard to dynamo machines of your construction only, and hence please state when and for what purpose the second dynamo machine constructed and used by you was first employed?

A. I cannot answer these questions with any great degree of accuracy without consulting my drawings to refresh my memory, for the reasons I have previously given. 164

x-Q. 117. Please state as near as you can how many dynamo machines of your construction were used by you for electric lighting or other purposes throughout the year 1879?

A. I shall have to consult my drawings to refresh my memory.

> Counsel for Brush here states that under the circumstances he is now obliged to discontinue his cross-examination with reference to the subject matter in hand, but will re-

165 sume again after the witness has made the desired examination of his records.

Counsel for Edison assents to the above course.

x-Q. 118. When and for what purpose did you first employ a dynamo machine built by other parties?

A. In the winter of '78 I employed a Wallace dynamo machine changed over into a magneto machine to work electric lights.

166 x-Q. 119. How long was that machine used by you?

A. It was used at various times, from October, November or December, 1878, up to the present time. There were two Wallace machines, one a small one and one a large one. The small one was borrowed while the large one was purchased. I think the large one was purchased some time in November or December, 1878. It is the large one that I still have now at my Goerck
167 street shop.

x-Q. 120. How lately was the large one used?

A. Within two months.

x-Q. 121. And was it used continuously through 1879, for electric lighting purposes?

A. No, sir; not continuously. I had other machines.

x-Q. 122. Was it used considerably or very rarely in 1879 for electric lighting purposes?

A. My impression is that it was used continuous-
168 ly in January and February, 1879; after that only occasionally.

x-Q. 123. When and for what purpose was the small Wallace machine first used?

A. I think in September or October, 1878, it was first used for the purpose of electric lighting.

x-Q. 124. How long was it so used by you?

A. I forget when it was returned but have an impression that it was sent back to Mr. Wallace in the spring of 1879.

x-Q. 125. During 1878 or 1879, did you use any

other construction of dynamo machines, except 169
your own and the Wallace machines referred to?

A. Yes, sir; I used the Weston nickel-plating machine and a Gramme machine.

x-Q. 126. When and for what purpose did you first use the Weston machine?

A. My impression is, in the absence of my data, that I bought a Weston plating machine in September or October, 1878, for experimental purposes in connection with electric lighting.

x-Q. 127. Did you employ the Weston machine 170
for producing the electric light; and, if so, how long was it thus employed by you?

A. At times we used it in experimenting on incandescence of metallic wires to determine certain phenomena and laws connected therewith. This machine was only used experimentally, it not being suitable for practical lighting.

x-Q. 128. When and for what purpose did you first employ the Gramme machine?

A. My impression is that I obtained the Gramme 171
machine in March or April, 1879, employing it for electric lighting at first, and afterwards for charging the field of force magnets of my own machines.

x-Q. 129. When did you first use it for the purpose last stated?

A. About March or April, 1879.

x-Q. 130. I now hand you the "Scribner's Monthly" for February, 1880, and desire to know if the statement attributed to you on page 531 was made by you? 172

A. Yes, sir; I made that statement to which my name is appended, but I desire to state that this article was written for popular use and is only generally correct.

x-Q. 131. About how long prior to February, 1880, the date of this magazine, was this article written by Mr. Upton, and your statement made?

A. My impression is that the article had to be prepared and delivered three months prior to publication.

173 x-Q. 132. At or about the time this article was written was Mr. Upton employed in any capacity by you or your company?

A. He was employed by me.

x-Q. 133. How long had he been in your employ and in what capacity?

A. My impression is he came into my employ in November or December, 1878. He was employed as a mathematician.

174 Counsel for Brush here introduces in evidence the copy of "Scribner's" referred to and designates the same "Brush Exhibit, Scribner's Magazine."

x-Q. 134. Who prepared your caveat signed December 26, 1879, to which you have referred in you direct examination?

A. I don't remember.

x-Q. 135. Can you ascertain the fact from your records?

175 A. I probably could. It was either L. W. Serrell or Z. F. Wilber.

x-Q. 136. I desire, if possible, to know which one of these gentlemen prepared this caveat, and as a means of refreshing your memory call your attention to the names of the witnesses, S. L. Griffin and Z. F. Wilber?

A. That does not refresh my memory, as I have an impression that Mr. Wilber had nothing to do with my cases until the first of January, 1880.

176 x-Q. 137. Are you confident then, that Mr. Serrell prepared this caveat?

A. No, sir; I am not.

x-Q. 138. Are you confident that Mr. Wilber did not prepare this caveat?

A. No, sir; I am not.

x-Q. 139. Was not Mr. Wilber on duty at the Patent Office until January, 1, 1880?

A. I don't know.

x-Q. 140. Will you please examine your records and accounts and make inquiry and state at a future period of this examination whether this caveat 177
was prepared by Mr. Wilber or Mr. Serrell?

A. I will endeavor to do so.

x-Q. 141. Please compare the invention shown, described and referred to in the first and second claims of the Brush Patent 224,511, and the invention shown and described, and pointed out in the second and third claims of your application in interference?

A. I have already testified on this relation and refer to my answer to x-Q. 83. 178

x-Q. 142. One difference between the two inventions referred to is that you employ a variable resistance in the circuit including the field of force magnets, while Brush employs a variable resistance in a shunt circuit including the field of force magnets. Is not this correct?

A. No, sir; the field of force magnets are not in a circuit in the Brush patent. They are in a main circuit and are shunted, as is clearly set forth in Mr. Brush's patent. 179

x-Q. 143. You are correct; but is not this one difference, that you employ a variable resistance in the circuit including the field of force magnets, while Brush employs a variable resistance in a shunt around the field of force magnets?

A. If this comparison is made between my application in interference and Mr. Brush's patent also in interference, it is correct to say, that I employ a variable resistance in the circuit containing the field of force magnets, and that Mr. Brush employs a 180
shunt containing a variable resistance, placed around the field of force magnets in the main circuit, both being very fully set forth in the application in question and the patent of Mr. Brush.

x-Q. 144. Also does not this difference in operation exist: In your application in interference the greater the resistance the weaker will be the field of force magnets, while in the patent of Brush the greater the resistance in the shunt, the stronger will be the field of force magnets.

181 A. That is the case. He would simply adjust his resistance to accomplish the same adjustment of the strength of the field magnets. He would add resistance while I would subtract resistance.

x-Q. 145. Is there not also this difference; that in the Brush patent there is shown and described a dynamo machine in the main circuit, said machine being provided with an adjustable resistance, whereby the strength of its own field of force magnets may be regulated, while in your application in in-
182 terference, there is no dynamo in the main circuit or adapted to be placed in the main circuit, which is provided with a variable resistance, whereby the strength of its own field of force magnets may be regulated. Is this true?

A. There is a dynamo machine placed in a circuit, the strength of whose own field of force magnets is regulated by a resistance placed in the circuit, but the machine or machines on the main line are not worked as dynamo machines, but as magneto-elec-
183 tric machines.

x-Q. 146. Then as I understand you, you do not in your application in interference show a dynamo machine in the main line.

A. Not in a main line, but in a subsidiary line, but I mention the use of both dynamo and magneto machines.

x-Q. 147. Will you please give a full description of the construction of the variable resistance used by you in the latter part of 1878 and fore part of 1879?

184 A. I used considerable lengths of wire which served as a resistance, stretching the same one length parallel with the other on a board, each stretch of wire being connected to a metallic pin, and more or less wire could be cut out by connecting the pins together by a wire. I also used magnet spools ranged so as to have more or less cut out. Also a cylinder round which wire was coiled, and a piece sliding over the face to cut more or less resistance out.

x-Q. 148. In your answer to question 10, direct,

you use the following language. "The same hav- 185
ing been on public exhibition in my laboratory since October, 1878." To what particular machine do you therein mean to refer?

A. The instrument referred to as having been used at my labratory, and on the lines of the Western Union Telegraph Company is the one shown in my patent 186,330; when I referred to its use in 1878 at my labratory, I referred to its use in connection with apparatus shown in patent 218,166 and the Wallace machine already referred to in my pre- 186
vious testimony.

x-Q. 149. In answer to question 18, you speak of an elaborate regulator made in 1879. Is that the one you have already put in evidence?

A. Yes.

x-Q. 150. Do you know of any publication made prior to Jauuary, 1880, giving a detailed description of the invention referred to in claims 2 and 3 of your application in interference. I mean a description of your invention?

A. I have not my scrap book by me to refresh 187
my memory, but find in a British patent which I have here by me, dated June, 1879, where the field of force magnets were energized by a separate circuit provided with appliances for regulating the strength of the current passing through the field of force magnets. It is No. 2,402 of June 17th, 1879.

x-Q. 151. You consider that a detailed description of the invention, do you?

A. It is as detailed as the first count in the inter- 188
ference.

x-Q. 152. In your opinion would an extra dynamo machine adapted to regulate the strength of the field of force magnets of another dynamo or magneto machine by varying the speed of such extra machine, be practically the same as your invention, set forth in the second and third claims of your application in interference?

A. The result as far as regards the regulation of the strength of the current passing through the

189 field of force magnets of the magneto machine would be the same in both cases; whether the difference in the methods of producing the result are patentable or different inventions I have not allowed myself to form an opinion.

x-Q. 153. In your opinion would a dynamo machine, the strength of whose current is regulated by the variable adjustment of the cores of its field of force magnets be practically the same as the invention specified in the second and third claims of your
190 application?

Counsel for Edison objects to the question as improper cross-examination; it being new matter, not relating to anything brought out in the examination-in-chief.

A. I decline to answer for the reason that, to be able to give an opinion I would have to invent a method of accomplishing the hypothetical object stated in the question, and would thus have to dis-
191 close a new invention not included in the interference.

x-Q. 154. Would it require invention to regulate the strength of a magnet by varying the adjustment of its core relative to the helix surrounding it?

Same objection as before.

A. It would probably require the invention of means proper and adequate to perform the adjustment.

192 x-Q. 155. In your application in interference you employ the words, "translating devices," what is comprehended by these words?

A. They are devices such as electro-motors or electric lamps, for translating electricity into light or power.

x-Q. 156. In your opinion would a variable resistance located in a circuit containing a dyna-mo machine and an electro plating apparatus, be practically the same as the invention referred to in

the second and third claims of your application in 193
interference?

Counsel for Edison objects to the question as new matter not brought out in the examination-in-chief of the witness.

A. I can't give any opinion, because I don't understand the question.

x-Q. 156. In your opinion would a dynamo machine located in a circuit containing an electro-plating apparatus, said dynamo provided with a variable resistance for regulating the strength of its 194
field of force magnets be practically the same as the invention referred to in the second and third claims of your application in interference?

Same objection as before.

A. Yes, sir.

By consent the taking of further testimony was postponed to Tuesday November 8th, 1881, at 10 o'clock A. M., at same place. 195

Wm. H. Meadowcroft,
Notary Public,
N. Y. Co.

Pursuant to adjournment the taking of testimony was continued on Tuesday, November 8th, 1881, at 10 o'clock A. M.

Present—N. S. Keith, in person; George W. Dyer, counsel for Edison; and H. A. Seymour, of 196
counsel for Brush.

x-Q. 158. Have you examined your records and ascertained when you first constructed a dynamo-electric machine?

A. No, sir, I have not. I have not had time.

x-Q. 159. Have you ascertained who prepared the caveat of December 26, 1879, and witnessed by S. L. Griffin and Z. F. Wilber?

A. I am told by Mr. Wilber that it was not made

197 by him, that he only signed it as a witness. Hence
it must have been made by L. W. Serrell, who was at that date my solicitor.

x-Q. 160. Do you recall to mind, or have you ascertained how it came about that Mr. Wilber, engaged in the Patent Office up to January, 1880, witnessed your caveat executed December 26th, 1879, and which was prepared by Mr. Serrell?

A. He was on a visit to Menlo Park.

x-Q. 161. By what incident do you recall the fact
198 that Mr. Wilber on or about that time, that is to say
some time in the latter part of 1879, suggested to you that the invention disclosed in the caveat in question might be a patentable invention, thereby leading you to file this caveat?

A. I remember that Major Wilber, in the latter part of 1879, was at Menlo Park studying up my business, with a view of taking a position with me after he had left the Patent Office.

x-Q. 162. How is it that you are enabled to recall
199 the fact that he suggested the patentability of this
particular invention at the time stated?

A. Because I remember it.

x-Q. 163. Is there no incident or circumstance in connection with this particular invention that serves to fix this fact in your memory, so that you are now enabled to testify thus positively on this point?

A. I simply remember the fact.

x-Q. 164. For what length of time in the latter part of 1879 was Mr. Wilber at Menlo Park, engaged
200 in studying up your matters, to prepare himself to
act in the capacity of counsel or attorney for you, in patent matters?

A. I should say a month or so; perhaps not as much as a month; I think he came over at different times.

x-Q. 165. Do you know that his whole time was given to your affairs during November and December, 1879, or that a portion of his time was devoted to your interest, and the remaining portion to his

duties in the Patent Office, of which he was an offi- 201
cer during the time specified?

A. All that I know is that he came to Menlo Park at different times in the last two months of 1879, and would stay two or three days at a time, and then go to New York, returning, perhaps, in three or four days afterward. He came to study up incandescent lighting, so as to fit himself to be attorney for me, having, I believe, permission from the Commissioner of Patents.

x-Q. 166. Did Mr. Wilber show you any authority 202
from the Commissioner of Patents to investigate your inventions, and at the same time to serve as an officer in the Patent Office?

A. I have already stated that Mr. Wilber came there to study electric lighting, with a view of becoming my attorney. I did not see any permission from the Commissioner of Patents.

x-Q. 167. Did you or did Mr. Wilber himself defray the expenses incurred in his numerous trips
from Washington to New York during November 203
and December, 1879?

A. I don't remember.

x-Q. 168. Please give us your best impressions in regard to this matter?

A. My impression is that I didn't pay him a cent.

x-Q. 169. Are you of the belief that Mr. Wilber paid these expenses?

A. I have already stated that I don't remember.

x-Q. 170. In your answer to question 9, direct,
you make the following statement: "In October, 204
1878, I varied the strength of the field of force magnets by an adjustable resistance which was in the circuit of the field magnet and not in a shunt around the same." I desire to know the particular construction of dynamo machine referred to in this paragraph, also the particular construction of the adjustable resistance therein referred to.

A. The machine to which this was applied is

205 shown in my patent, 218,166. The resistances which I used I now proceed to make a sketch of.

Sketch offered in testimony and marked "Edison's Exhibit No. 8."

Figure 1 consists of a board provided with metallic pins between which wires were stretched and electrically connected with the pins, more or less wire being inserted in the circuit by twisting another wire around the pins *a' a' a'*. Figure 2 represents the same method in which spools or coils of
206 wire were used. Figure 3 shows an insulated cylinder on which German silver wire was wound, each wire insulated from the others, and by means of a sliding contact, S, more or less turns could be put in the circuit. These variable resistances were used to vary the strength of the field of force magnets in the dynamo shown in patent 218,166, as we had difficulty in getting that instrument to make its own field when the field magnets were included in the main circuit.

0 x-Q. 171. Please indicate, on the drawing of this patent, the particular circuit in which this variable resistance (I mean any one described by you), was located?

A. The magnets marked *c, c'* were the ones in which the resistance was placed, but the connections were not as shown in the patent. The magnets were placed in a local circuit containing a battery and an adjustable resistance.

x-Q. 172. With the machine changed as you have
208 explained, was it a dynamo or magneto electric machine?

A. It was a magneto electric machine.

x-Q. 173. Before this change was made, I understand that the machine did not operate satisfactorily. Am I correct?

Question objected to upon the ground that the witness has not made any such statement as that implied in the question.

Counsel for Brush states that the question is properly put in view of answers to cross-ques-

tions 108 to 110 inclusive, and cross-question 209
170. However, if he is in error he has no doubt as to the ability of the witness to correct him.

A. I don't see how you could understand this from the testimony.

x-Q. 174. You have stated that you altered the machine shown in patent 218,166: this change consisting in placing a local battery and a variable resistance in the circuit of the magnets *c c'*. Why was this change made? 210

A. It was made because the machine did not make its own field sufficiently to give a current of the desired strength.

x-Q. 175. Then before this change was made the machine did not operate satisfactorily, did it?

A. We did not get a current of the desired strength.

x-Q. 176. And you made this change in order that the machine should operate satisfactorily, did you not, that is, give the desired strength of current? 211

A. We made the change with a view of getting a stronger current. We got a stronger current, but it was not of the desired strength.

x-Q. 177. And for the reason last given was not the machine discarded, and other forms used by you in lieu thereof.

A. The machine was laid aside for the reason that we had great trouble with our steam cylinders and valves, and for the further reason that we thought we could make a better machine. 212

x-Q. 178. After you had corrected the trouble with reference to the steam valves, etc., did you ever resume the use of this machine changed as you have described?

A. I did not say that we corrected the trouble with the steam valves.

x-Q. 179. Did you correct the trouble with steam valves that you referred to, or are you now bothered and troubled by such defective devices?

213 A. We were bothered by the steam valves; we are bothered now by steam valves.

x-Q. 180. Would you have it understood that the particular machine in question is of that peculiarity that it cannot be operated owing to defective steam valves, and hence was laid aside for that reason, while other forms of machines are not affected in this peculiar manner, and hence have been adopted by you?

A. The machine in question was very difficult to
214 operate, especially the valves, as the amplitude of the reciprocating parts differed, whereas to make a valve operate properly, the mechanism should all have positive motions; these positive motions are of course obtained when we run the present form of dynamo machine by a steam motor having a valve; yet these valves give a good deal of trouble, notwithstanding they work by a positive motion.

x-Q. 181. Was the machine altered in the manner you have described, the one you have referred to in
215 answer to cross-question 108?

A. The machine referred to in cross-question 108 was the same as that shown and was connected as in Patent 218,166.

x-Q. 182. Please state the time the change you have referred to was made?

A. I think it was made some time in November, 1878.

x-Q. 183. As your application for Patent 218,166, the patent in question, was not filed until December
216 9th, 1878, and the change you have referred to was, as you state, made in November, 1878, will you please explain why you failed to disclose in your application for the patent in question the machine in the changed form, that is, provided with the local battery and variable resistance, whereby the strength of the current was increased?

A. For the reason that I desired to patent a steam tuning fork acting as a dynamo machine as my claims will show, and I put it in the form of a dynamo machine, as that method was known in the art,

and in my patent No. 222,881, the machine is shown 217
as a dynamo machine, notwithstanding that I disclaim the use of it as a dynamo machine in the specification, and for a further reason, perhaps, that I didn't think such combination patentable, that is to say, the use of an adjustable resistance with the field of force magnets as I have already testified.

x-Q. 184. In answer to question 10, direct, you speak of using an adjustable resistance with a Wallace machine in October, 1878. Please describe the construction or type of the adjustable resistance, 218
and state just how it was connected with the machine.

A. I make a sketch which shows the Wallace machine. There are two commutators, A and A′; the machine being a duplex machine. F, F, F, F, are the field magnets; C the rotating magnets. In one case one side of the machine was used as a dynamo, in the circuit of which were the field magnets of the other half of the machine, in the circuit of which was placed an adjustable resistance R, for regulating 219
the strength of the machine. X, X, is the main circuit.

In figure 2, the commutators of both machines were connected in the main circuit. The fields of both machines were connected in another circuit containing an adjustable resistance R, which circuit was multiple arcd across a main circuit, X, X.

Sketch referred to put in evidence and marked "Edison's Exhibit No. 9."

Batteries were also inserted in a local circuit entirely disconnected from the line, containing a variable resistance, for energizing the field. 220

x-Q. 185. You have described three different forms of connections. Please state which one was first used?

A. The one with the battery, I think, was the first used.

x-Q. 186. When was the one with the battery first used?

221 A. Within a few days after I got the Wallace machine.

x-Q. 187. How long was it used?

A. I don't remember the length of time it was used. Possibly, it might have been used for a week.

x-Q. 188. Which of the forms was next used?

A. Figure 2 was the next form used.

x-Q. 189. How long was it used.

A. Only a few days, I think, at one time.

222 x-Q. 190. When did you first use the form shown in figure 1?

A. Within a few days after that in figure 2. When the arrangement shown in figure 2 was used, it would burn out coils in the resistance, as the field magnets were not wound in a proper manner to use it in this way with economy.

x-Q. 191. Please explain why you changed from the form first used to the form shown in figure 2?

A. We didn't have enough battery was one reason,
223 and what we did have weakened rapidly.

x-Q. 192. Now please state as near as you can the date you first commenced using the form shown in figure 1 and the length of time the machine was used as there shown?

A. The machine and method of connecting as shown in figure 1 were used as nearly as I can remember in October or November, 1878. It has been used on and off ever since that date, sometimes in one way and sometimes in another.

224 x-Q. 193. Please state what you mean by "sometimes in one way and sometimes in another?"

A. The field magnets of both sides of the machine have been energized by another machine. That is another use of the machine.

x-Q. 194. That relates to a form not illustrated in figure 1. Please answer cross 192, confining your answer to the particular form of connection shown in figure 1?

A. The machine connected and operated exactly

as shown in figure 1 has been used at different 225
times by me since that date.

x-Q. 195. When was it first changed so that the field of force magnets were energized by a separate dynamo?

A. I think it was in February or March, 1879. That is my impression.

x-Q. 196. Of what type or construction was this separate dynamo?

A. It was another Wallace machine.

x-Q. 197. Was it the small Wallace machine of 226
which you have testified and which you returned?

A. Yes, that is my impression.

x-Q. 198. In answer to question 10 direct you refer to the lamps you were experimenting with in 1878. If such lamps have since been patented will you please designate the patents, showing their construction?

A. These lamps are shown in patents 214, 636; 227, 227; 227, 228; and 227, 229.

x-Q. 199. Do your patents show any other con-
struction of lamps experimented on in connection 227
with a dynamo provided with a variable resistance, as called for by the issues of this interference—say up to April, 1879?

A. I do not find any in my book of patents, other than those referred to.

x-Q. 200. In your caveat filed August 7th, 1879, you refer to three different plans for regulating the current of a circuit containing electric lamps. Please state if you are now employing any one of the plans
therein suggested for the purpose stated? 228

A. None of the plans for regulating the electromotive force that I notice in the caveat are used by me at the present time. The caveat was to put on record various methods for accomplishing the regulation of the electro-motive force in a system of electric lighting.

x-Q. 201. Did you ever put into practical use any of the several plans proposed in the caveat in question?

A. Yes, sir; I believe I have.

229 x-Q. 202. Prior to August 7th, 1879?

A. Yes, sir.

x-Q. 203. Will you explain why it is that you do not employ any of the plans therein referred to, at the present time?

A. I refuse to do so.

x-Q. 204. Will you explain why it is that in the caveat, wherein you have described three different plans, you fail to explain the plan comprising the improvement in interference, and which you state
230 you put into actual use in the fall of 1878, and are using to-day?

Question objected to, so far as it may relate to the actual construction which Mr. Edison is using now, for the reason that Mr. Edison is not called upon to divulge matters which are properly his own secrets, or the secrets of the Patent Office.

Counsel for Brush states that he has no curi-
231 osity to learn anything of the thousand and one inventions of Mr. Edison; that by words of express limitation he has confined his question to the improvement in interference, and that he has no wish, desire or expectation of drawing from the witness any information except that which properly bears upon the question in issue.

A. The reason why is this: that I did not think the device now in controversy was patentable while
232 I thought those described in the caveat might be worked up in proper combinations and patented, and I have since applied for some combinations in which these methods of regulating are used, and it will be noticed that the caveat expressly states that the inventions consist in various devices to produce an even or equal electro-motive force in the circuit to moderate the power of the light without the interposition of devices wasteful of electric energy. A variable resistance would be the interposition of

of a device wasteful of electric energy, and this is 233
what the caveat expressly states is not the object.

x-Q. 205. You stated, I think, in your former examination that you would try and find the machine which you constructed in accordance with your patent 218,166. Did you succeed in finding this machine?

A. I have not had time to look, but will do so at the earliest possible date.

x-Q. 206. In your answer to question 19 you refer to a sketch of resistance coils. If this construction of coil had been used since September, 1878, can you 234
explain why no record was made of it until, or a record was made of it at all, in March, 1879?

A. We didn't need any record or sketch. The reason why the record Exhibit No. 1 was made was that a record could be kept of the work done in the shop.

x-Q. 207. Is there anything about this resistance coil showing that it is adapted for any particular purpose, or is it intended and adapted to be used for any of the purposes for which such resistance coils 235
are used?

A. It could be used for any purpose, but it is especially adapted to be used with dynamo machines as the wire is bare and is spread out so the air can come in contact with it to cool off the heated wire.

x-Q. 208. In answer to question 25 direct, you refer to sales of dynamo machines provided with variable resistances having been made since February, 1879, will you please give the address of any of the parties to whom you sold a dynamo machine 236
provided with a variable resistance for regulating the strength of its field magnets, during any portion of the year 1879?

A. I stated that this kind of resistances was used since 1879, and is *now* furnished with each machine sold to the public. I desire to state that the reason why we did not sell many machines to the public was my disinclination to go into a peddling business of selling small machinery to the public, my object being to distribute electricity

237 over large areas by a system of general distribution analogous to that of gas.

x-Q. 209. Did you sell any machines such as I have referred to in 1879?

A. No, sir; I don't remember any.

210 x-Q. In answer to cross-question 88 you state that in a dynamo machine constructed in accordance with patent 219, 393, the resistance increases according to the increased speed of revolution of the contact cylinder. Is this correct?

238 A. Yes, sir.

The further cross-examination of this witness is suspended by consent of parties.

By consent of parties, the testimony of Z. F. Wilber was taken at this point, November 8, 1881.

Examination of Thomas A. Edison resumed on Saturday, November 12th, 1881.

239 RE-DIRECT EXAMINATION BY RICHARD N. DYER, OF COUNSEL FOR EDISON:

Re-d. Q. 211. Referring to your answer to cross-interrogatory 128, as to the time when the Gramme machine was received at Menlo Park, have you not since consulted memoranda and refreshed your memory, and do you not now find that you were mistaken as to the date given by you in said answer?

240 A. Yes, sir. I find by looking over the correspondence of the Edison Electric Light Company and some of my records kept at the laboratory, that I received the Gramme machine some time between January 3d and January 22d, 1879.

Re-d. Q. 212. Referring to your cross interrogatories in regard to various patents of your own, commencing with number 160,405, do not these patents show, and is it not a fact, that from the date of the invention set forth in the first of these patents, you understood fully the conditions necessary to be employed in the regulation of the strength of simple

electro-magnets by an adjustable resistance; and has not this method of regulation, in one form or another, been constantly employed by you since that time? 241

Objected to as leading, incompetent and immaterial.

A. Yes; the use of an adjustable resistance for regulating the strength of the current in a simple electro-magnet has been used by me at various times since July, 1873, and in connection with a dynamic machine, the dynamic machine and the variable resistance being combined together to admit of such 242 an arrangement being used to experiment on devices requiring electric currents; and I understood fully the uses and the methods of operation of these variable resistances applied to a simple electro magnet and they were not the subject of experimentation, but were practical devices, or rather a practical device applied to a dynamic machine, the currents from which were to be used for electric lighting purposes since the fall of 1878. 243

THOMAS A. EDISON.

Z. F. WILBER, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and occupation?

A Z. F. Wilber, age 39; residence, New York City; occupation, patent solicitor. 244

Q. 2. I call your attention to the testimony of Mr. Edison contained on the seventh page of the printed record from which I quote: "But I never made a claim to the use of an adjustable resistance in the circuits of such field magnets, until my attention was called to the fact by Major Wilber in the latter part of 1879, that this might be patentable." Do you remember the fact as stated by Mr. Edison as above, and if so what is your recollection of the occurrence?

245 A. I remember of making several suggestions as to probable patentability to Mr. Edison, of devices or arrangements used by him, among which was his way of regulating his circuit. It occurred at one of the visits I made to Menlo Park in the early winter of '79-'80. I was struck by the exceeding simplicity of his method for regulating the current in order to compensate for fluctuations in the number of lamps in circuit, and I suggested to him that it was patentable and important.

246 Q. 3. Have you a distinct recollection whether this occurred during the year 1879 or in 1880?

A. I have no distinct recollection of the exact month or year.

Q. 4. Can you remember how many times and for how long a period you visited Menlo Park during the months of November and December, 1879?

A. No, sir; I cannot, I can only fix the fact by record.

247 Q. 5. For what purpose did you go to Menlo Park on those occasions?

A. To become as thoroughly acquainted as possible with Mr. Edison's systems of electric lighting.

Q. 6. Did you go there at his request or upon your own motion?

A. I went there upon my own motion.

Q. 7. At your expense or at Mr. Edison's.

A. At my own expense.

Q. 8. By permission, or without permission of the Commissioner of Patents; which?

248 A. By permission of the Commissioner of Patents.

Q. 9. Was there anything peculiar in such visits, or out of the course usually pursued by officials in the Patent Office, so far as you know.

A. Not so far as I know.

Q. 10. Had you been in the habit of visiting other establishments?

A. I had visited establishments several times to became acquainted with the arts to which they related, generally at my own expense, a few times

at the expense of the people whose establishments I visited, or at the expense of people who had machinery there. 249

Q. 11. While you were in the Patent Office had you visited other establishments than Mr. Edison's connected with electrical matters. If so, whose.

A. Several, remembering now the Western Union shops under Mr. Phelps, now the Western Electric; the Towle and Unger shops; the Foote and Randall shops; the Chester shops in this city; Davis and Watts in Baltimore; the Western electric in Chicago; Jesse Bunnell's when he was in Philadelphia; 250
I have forgotten the name of the firm, and two or three small shops in Cincinnati in 1875, whose names I don't remember. I was also requested I think in 1876 by General Leggett to visit Cleveland and see the Brush light, and whatever they had to show, at their expense. I was for some cause, unable to go, and sent my then first assistant, Mr. Townsend who visited what they then had in Cleveland, at their expense with the knowledge and consent of the Commissioner. The visits of my own 251
that I spoke about were all at my expense.

Q. 12. State whether or not while you were an official in the Patent office you did any work for Mr. Edison of any character; for which you received or expected to receive compensation.

A. I did not.

Q. 13. Do you remember how it happens that your name appears as a subscribing witness to a caveat of Mr. Edison's filed December 26th, 1879? 252

A. I do not remember the circumstances of the caveat. It must have occurred because I was present and saw him sign it, just as I should have witnessed it had I seen him sign it in Washington, a thing which I, while an officer in the Patent Office, and other officers in the Patent Office, have often done.

Cross-examination by H. A. Seymour:

x-Q. 14. Mr. Edison has stated in effect that you

253 visited Menlo Park during the months of November and December for the purpose of studying up his inventions, in order to prepare yourself to serve as his attorney or solicitor upon your leaving the Patent Office. This is true, is it not?

A. It is true.

x-Q. 15. Now, when you obtained the permission of the Commissioner of Patents to make these visits, did you acquaint him with the fact that the objects of your visits were as above stated?

254 A. To answer this question fairly and with justice to myself, I ought to go back a little and state that after having made my arrangements to leave the office, I desired the customary thirty days' leave. The work of my division—Interferences—was very much behind, a number of cases having been heard in which decisions had not yet been rendered. It was necessary for me to sign those decisions, as I had heard the cases. The Commissioner and myself, therefore, arranged that, as soon as possible,
255 he would designate my successor, that I could leave to him then the hearing of the cases, and use such time as was necessary to bring up the old work, and the remaining time use as I pleased, two or three days or a week at a time, instead of taking the thirty days in one lump; and, as a matter of fact, I heard no cases whatever during the month of December, 1879, and I do not think that I heard any after the 10th or 15th of November. Under this arrangement I do not recollect that I specifically in-
256 formed the Commissioner of where I spent the time during which I was absent from the office, although he early knew that I was to take charge of Mr. Edison's patent business.

x-Q. 16. Was this arrangement between the Commissioner of Patents and yourself made orally, simply?

A. Simply made orally.

x-Q. 17. You state that you made several suggestions to Mr. Edison at or about the time in question. Do you know that Mr. Edison adopted your sugges-

tions in other matters as in the matter in hand, and filed caveats for unprotected inventions. 257

A. I do not know whether Mr. Edison acted on my suggestions at all, but I do know that when I took charge of his patent matters, I acted upon them and filed the proper applications.

x-Q. 18. Did you file Mr. Edison's original application, of which the application in interference is a division?

A. I did.

x-Q. 19. Will you explain why it was that you divided the application? 258

A. While the original application was pending, the Patent Office for some reason or other issued to Mr. Brush a patent, covering a portion of such pending application. The remaining portion of that application was not affected by Mr. Brush's patent, and hence I exercised our right of dividing into an interfering and non-interfering application.

x-Q. 20. You say in your last answer "the Patent Office for some reason or other issued to Mr. Brush 259
a patent, covering a portion of such pending application." Have you any reason to believe that this was not done by a mere oversight on the part of the examiner having charge of the cases. In other words, that he overlooked the Brush application, it having already passed to issue.

A. I have made no charges in this connection. I have merely stated the fact. I am not going to state whether I have any opinion, good, bad, or indifferent in the matter. 260

x-Q. 21. Have you any reason to believe that the examiner was aware of the fact that the Edison application in question was pending or had been filed prior to the actual grant of the Brush patent?

A. Prior to the issuance of the Brush patent I had called the attention of an assistant examiner, into whose hands I knew the original application before referred to would go for action, to the fact of its filing.

x-Q. 22. For what purpose did you call the atten-

261 tion of the examiner to the filing of this particular case.

A. In order if there were any pending applications showing the same thing or things as any or all things in that application, that such an issuance of a patent as did afterwards happen in this case might be prevented.

x-Q. 23. Was not that rather an extraordinary proceeding, to advise the examiner to do the very thing that he should have done; if he had performed his
262 duty and complied with the rules of practice.

A. I did not advise the examiner to do anything.

x-Q. 24. Is this your ordinary procedure in filing cases, to consult the examiner with reference to all the cases filed by you for your clients?

A. I have said nothing about ordinary procedure or about consulting the examiner; I do not understand the question, unless the gentleman wishes to ascertain how I transact my business.

x-Q. 25. I desire to know, in short, if you are in the
263 habit of calling the attention of examiners in the Patent Office to cases as you file them; if not, what impelled you to call the attention of the examiner to this particular case.

A. While I do not call attention to every case filed I do frequently, upon the filing of a case, or as soon thereafter as I can see the examiner, especially when the invention has been exhibited or experimented with publicly, call his attention to the fact that I am about to file an application covering
264 such and such purposes.

x-Q. 26. At the time you called the attention of the examiner to this case, or about that time, do you remember whether or not there was anything said by you or by the examiner relative to the application of Brush, then pending.

A. Nothing whatever was said; I never knew that Mr. Brush had an application pending until I saw the notice of the patent in the Gazette.

Z. F. Wilber.

The taking of further testimony was adjourned by consent to Wednesday, November 9th, 1881, at 10 o'clock A. M. 265

Wm. H. Meadowcroft,
Notary Public,
New York County.

Pursuant to adjournment, the taking of testimony was continued on Wednesday, November 9th, 266
1881, same parties being present.

Francis Jehl, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and occupation?

A. Francis Jehl; age, 22; occupation, assistant to Mr. Edison; residence, 101 East Twentieth street, New York. 267

Q. 2. State when and where you first went into the employ of Mr. Edison?

A. I was engaged in February, 1879, and commenced to work at the laboratory in Menlo Park on March 3d, 1879.

Q. 3. What was the first work you were engaged in?

A. I assisted Mr. Upton in beginning some experiments, making some resistance boxes, adjusting them, &c.

Q. 4. When you went into Mr. Edison's employ 268
did he have in use dynamo machines. If so, of what kind and how many?

A. We did. I remember two; one known as the Wallace machine and the other known as the Gramme.

Q. 5. Did either of these machines or both of them at that time have devices for primarily varying the strength of the current energizing its field

269 of force electro magnets; and if so, what description of means were so employed?

Question objected to as leading.

A. They had. There was a sort of resistance—zig-zag like—by which certain lengths of the wire could be cut out or put in so as to increase or diminish the current which circulated through the magnets of the dynamo machine and thereby increasing or diminishing the main current.

270 Q. 6. Did you work on the construction of any resistance coils after you went into the employ of Mr. Edison; if so, when, and of what character were the resistance coils?

A. I did. It was in the early part of March, 1879, that I began to adjust and wind some resistance boxes for the purpose of regulating the current in dynamo machines, as the arrangement we had before that time was rather crude.

Q. 7. Please examine Exhibit No. 1, now shown

271 you, and state whether the resistances you have just testified about were of the character and description shown in that exhibit?

A. They were.

Q. 8. Do you know what was done with those resistances after they were made?

A. Yes, sir; they were substituted in place of the zigzag resistances used in experiments on electric light.

Q. 9. Do you mean they were actually put in use

272 in connection with dynamo machines?

Objected to as leading.

A. I do.

Q. 10. How long continued was such use of such resistances, or those of a similar kind and character, in connection with dynamo machines, for varying the strength of the current of the field of force magnets?

Objected to for the reason that the witness

has not yet testified that any other forms of 273
resistances were ever used.

A. Ever since I've been with Mr. Edison I have known him to use resistances for such purposes.

Q. 11. Please look at the exhibits already introduced in testimony in this case, marked Edison's Exhibits, Nos. 2, 3, 4, 5, 6 and 7, and state whether or not you recognize any of them. If so, when and where did you first see them?

A. I recognize all of them, and saw them when I
first went to the laboratory at Menlo Park. 274

Q. 12. Did you see any or all of them in actual use at Menlo Park; and if so, please state in what connection as to machines, and for what purposes?

Objected to as leading, the witness not having testified that he has ever seen these exhibits in connection with any machines whatever.

A. I have seen them in actual use. I remember
seeing them in connection, or, rather, in circuit with 275
the Gramme machine, which was used for exciting the magnets of the Wallace machine. I also remember seeing them used on the Wallace machine alone. The Wallace machine we had there was one known as a duplex machine, or in other words, it was two machines combined into one. The resistance coils were connected in circuit with one part of this machine, and the current used to excite the magnets of the other part. Then, again, I have
seen just the reverse of this—the Wallace used as 276
an exciter to the Gramme. The object was to increase or diminish the main current for experiments with electric lighting.

CROSS-EXAMINATION BY H. A. SEYMOUR, COUNSEL FOR BRUSH:

x-Q. 13. Prior to your employment by Mr. Edison, in what business were you engaged, or what was your occupation or profession?

A. I was engaged at the Western Union Telegraph

277 Company; my occupation was working on telephones; at that time I was a novice in that business.

x-Q. 14. At what time were you a novice in that business—when employed by the Western Union or when first employed by Mr. Edison?

A. When employed by the Western Union, and also at my early engagement with Mr. Edison.

x-Q. 15. When did you first make the acquaintance of Mr. Edison?

A. I believe it was in 1876 or '77.

278 x-Q. 16. You state in answer to question 2, direct, that you were engaged by Mr. Edison in February, 1879; at what time in February were you thus engaged?

A. I should say it was about in the middle of the month.

x-Q. 17. When did you first visit Menlo Park?

A. About ten or twelve days after my engagement.

x-Q. 18. Did you go through the shops or labora-
279 tory and examine Mr. Edison's improvements prior to March 3d, 1879, when you first commenced work for Mr. Edison?

A. No, sir.

x-Q. 19. When you commenced work for Mr. Edison, did you enter his employment to serve in any sense as an electrician to assist him in that line of research?

A. No, sir; merely to assist him in whatever he wanted done.

280 x-Q. 20. About how many persons or workmen were then in the employ of Mr. Edison?

A. I should say about thirty.

x-Q. 21. Were these thirty workmen designated as assistants, or as machinists, and carpenters, and ordinary workmen, doing odd jobs as called upon?

A. They were nearly all workmen doing odd jobs, as you say, the majority of them being machinists.

x-Q. 21½. And you were employed as an ordinary workman, were you not?

A. No, sir; I was employed to assist Mr. Edison in the laboratory to carry out little experiments 281
which he gave me to do.

x-Q. 22. At that time were you familiar with and experienced in matters relating to electricity, that is understood the science?

A. I had studied and worked with electricity before I entered Mr. Edison's employ and experimented with such apparatus as I could afford to make or buy.

x-Q. 23. Please explain the character of your work while employed by the Western Union Com- 282
pany?

A. There it was merely as a workman on telephones. The work not being the kind I liked, I strove for a better place where I could have a better opportunity to experiment, and on this account I went to Mr. Edison.

x-Q. 24. Did you ever take out a patent relating to any improvements in electrical apparatus?

A. No, sir.

x-Q. 25. How many assistants did Mr. Edison 283
employ in his laboratory to assist him in making experiments?

A. About five or six.

x-Q. 26. And the duties of these assistants were simply to do such mechanical work as was necessary to carry out the instructions of Mr. Edison in making experiments ordered by him. Is not this true?

A. Their duties were to carry out such ideas and suggestions as Mr. Edison gave, and to experiment 284
with them in order to obtain the results he anticipated. They were both mechanical and electrical.

x-Q. 27. Will you please give me the full names of the other assistants employed in Mr. Edison's laboratory at that time, namely, March 3d, 1879?

A. There was Mr. Charles Batchelor, Mr. John Kruesi, Mr. Francis Upton, myself, Mr. Martin Force. That's all I can remember now.

x-Q. 28. Who had charge of this force of employees?

285 A. I believe Mr. Edison.

x-Q. 29. I mean especial charge of the employees in the laboratory.

A. There was no such system as they have in shops in the laboratory then. Mr. Batchelor was looked upon as the man in charge, but everybody helped and worked where he was most needed in anything.

x-Q. 30. How long were Mr. Upton and yourself engaged in March, 1879, in your experiments on re-
286 sistance boxes?

A. About two weeks.

x-Q. 31. At that time did you know for what purpose these resistance boxes were to be used?

A. Yes, sir.

x-Q. 32. In March, 1879, did you see any other dynamo machines at Menlo Park except the two you have referred to—namely, the Wallace and the Gramme machines?

287 A. Yes, sir; there was one in a case in the laboratory, but which I did not see used at that time or in those experiments.

x-Q. 33. Any other?

A. I might say yes. There were many small experimental machines of almost an endless variety.

x-Q. 34. Were these small experimental machines of endless variety constructed and adapted to do practical work in electric lighting or were they mere experiments only?

A. They were experiments.

288 x-Q. 35. Did you ever see the other machine that was in the case in actual operation?

A. I don't remember, as they experimented on this machine before I came there.

x-Q. 36. Did you witness such experiments?

A. No, sir.

x-Q. 37. Then, as a matter of fact, you have no personal knowledge whether that machine was or was not experimented with before you went to Menlo Park?

A. I have no personal knowledge.

x-Q. 38. Was the machine last referred to one of 289
Mr. Edison's inventions?

A. It was.

x-Q. 39. In March, 1879, were the Wallace and Gramme machines used as dynamo or as magneto-electric machines?

A. I remember, in all the experiments in which I was engaged, they were used as magneto machines. By that I mean that the magnets were charged from another machine with resistance in the line.

x-Q. 40. Then both machines were used at the 290
same time, or in connection with each other, to generate the main current, were they?

A. Yes, and sometimes one alone. The magnets, being multiple arcd with the bobbin, resistance, of course, being in the magnet line.

x-Q. 41. What do you mean by "multiple arcd with the bobbin?"

A. I mean that the magnets, with their adjustable resistance, were shunted around the bobbin.

x-Q. 42. When was the method last referred to 291
first resorted to, so far as your personal knowledge goes?

A. When I first went into the laboratory.

x-Q. 43. The resistance then employed was of the zig-zag type, was it?

A. Yes—a portion of it. I also remember the boxes I see over there, exhibited in this case, as being in use.

x-Q. 44. Were the two forms of resistances employed at the same time?

A. I don't exactly remember. I do remember 292
that they were used in connection with the experiments above described.

x-Q. 45. Did the zig-zag resistance prove satisfactory in use?

A. Yes, sir, as far as satisfaction is concerned, but to get the same resistance in a smaller compass we wound them around boxes.

x-Q. 46. In the use of the zig-zag resistance was

293 any trouble met with owing to the burning of the wires?

A. I believe the wires did heat.

x-Q. 47. Do you not know that that was the fact?

A. I do.

x-Q. 48. And for that reason the resistance boxes were substituted in their place, were they not?

A. That, no doubt, is one of the reasons.

x-Q. 49. In March, 1879, please explain fully the particular work performed by you on these resist-
294 ance boxes?

A. Such as making them, or rather making the wire a certain length, so as to equal a certain unit or part of a unit called the ohm, which is the unit of resistance?

x-Q. 50. How many zig-zag resistances were in use when you went to Menlo Park?

A. I remember only the one that I have spoken of.

x-Q. 51. How was that used or connected at that time?

295 A. It was in circuit with a machine used to excite the magnet of another machine.

x-Q. 52. Please describe the manner in which Exhibits 2, 3, 4, 5, 6 and 7 were used at Menlo Park from the time you first went there, and if any changes were made in their use please explain such changes?

A. The whole apparatus was divided in two parts, one on the ground floor of the laboratory and the other part on the floor above it, connected by the
296 rods marked Exhibit 6. The resistance boxes were on the upper floor, and cut in and out by means of Exhibit 7, which was connected to the rods, the upper end of the rod being connected with a kind of switch-board, marked Exhibit No. 5. The old boxes were then substituted for the new ones that we made.

x-Q. 53. Then, as I understand you, the rheotome marked Exhibit No. 5 and the parts designated as Exhibits Nos. 6 and 7 in connection with the resistance boxes were arranged as you have described, at the

Menlo Park laboratory, in March, 1879, when you 297
went there; am I correct?

A. You are.

x-Q. 54. How long were these parts used in the arrangement you have explained?

A. They have been used from that time, when I was there, till four or five months after that exhibition, which was in 1880, I guess.

x-Q. 55. What became of the Wallace machine you have spoken of?

A. It remained at the laboratory until recently 298
it was sent to the machine works in New York and stored away.

x-Q. 56. What became of the Gramme machine?

A. It was sent to California, if I am not mistaken.

x-Q. 57. Have you read the testimony of Mr. Edison in this case?

A. No, sir, I have not seen it, only this morning I saw the pamphlet.

Cross-examination ended.

Mr. Keith declines to cross-examine the 299
witness.

Francis Jehl.

John Kruesi, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed to him by Geo. W. Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and
occupation. 300

A. John Kruesi; age, thirty-eight; residence, 49 Putnam avenue, Brooklyn; occupation, Treasurer of the Electric Tube Company.

Q. 2. State whether or not you have been in the employ of Mr. Edison, and if so, from what time to what time, and in what capacity?

A. I have been in Mr. Edison's employment for nine years, with one short intermittence of six months. First as an instrument maker; for the

301 last five years as foreman of the mechanical department.

Q. 3. Were you in his employ during all the time of the years 1878, 1879, and 1880?

A. Yes, sir.

Q. 4. When did you first know of his having and using dynamo-electric machines?

A. It was about September, 1878.

Q. 5. How many of such machines and of what general character or name?

302 A. We had first a small Wallace machine. Then we received in exchange for that a large Wallace machine and a Weston machine, and also a Gramme. Then we built a number of machines ourselves of the Edison type.

Q. 6. State when you first knew Mr. Edison to combine a dynamo-electric machine with suitable devices for primarily varying the strength of the current exciting its field of force electro magnets.

A. The first that I remember, I think was in De-
303 cember, 1878.

Q. 7. State, if you remember, the kind of machine and the connecting mechanism for varying the strength of the current as aforesaid?

A. I do not clearly remember whether it was used on the Wallace machine, but I think so. To the best of my recollection it was used on the Wallace machine. We used magnet spools first and after resistances made of wire or sheet metal zigzag on a board.

304 Q. 8. What, if anything, was used after that?

A. We used wire wound on wooden spools so that the wire was exposed to the air all around, or as near as possible, in order to cool it off.

Q. 9. Did you use any means at that time or at an earlier day to adjust the resistance?

A. We had numbers of these spools and plugged them in or out to suit the circumstances.

Q. 10. How long was the use of adjustable resistances in connection with a dynamo-electric machine continued?

A. From early '79 up to to-day.

Q. 11. Can you fix any date in early '79? 305

A. It must have been February or March. There are notes, though, in books which give the date more definitely.

Q. 12. Were these resistance coils on frames such as you have described used directly after the zigzag wire resistance and magnet spool resistance that you have before named?

A. I think so.

Q. 13. Since some time in the fall of 1878, have 306 you known Mr. Edison to use any dynamo machines without means for primarily varying the strength of the current of the field of force electro magnets or dynamo-electric machines without adjustable resistances to regulate the strength of the current of the field of force electro-magnets.

A. For special experiments only, such as with arc lights, he didn't employ adjustable resistance; bu for his experiments on incandescent light he always used an adjustable resistance.

Q. 14. Was that the case with the dynamo ma- 307 chines which he made, as well as those which he used of the make of other parties?

A. Yes, sir.

Q. 15. Please examine the Exhibits 2, 3, 4, 5, 6 and 7 in this case and state whether or not you recognize them, and when and where you first saw them, to the best of your recollection.

A. Yes, I recognize them as being made at the
Menlo Park Machine Shop. No. 2 was made in 308
February or March, '79; Nos. 3 and 4 shortly after; Nos. 5, 6 and 7 about November, '79.

Q. 16. What use were Exhibits No. 2, 3 and 4 put to at Menlo Park?

A. For varying the electro motive force of dynamo electric machines.

Q. 17. Do you remember how long they were so used?

A. I do not remember how long these particular

309 ones were used. We had a large number, and some were in use all the time.

Q. 18. Why was the arrangement made use of which occasioned the employment of the Exhibits 5, 6 and 7?

A. They were used to enable the men to regulate the electro motive force of the machines from a distant point.

Q. 19. Do you remember how long these particular parts were kept in position at Menlo Park, and
310 why they were taken down?

A. They were in position from about November, '79, until the time I left Menlo Park, which was in February, 1881, and I left them in position then.

Q. 20. Please examine Edison's Exhibit No. 1, now shown you; state whether or not the letters "J. K." at the bottom of the same are in your handwriting and are the initials of your name?

A. Yes, sir.

Q. 21. Do you remember making the resistance
311 coils there shown and described? If so, what date did you make them?

A. Yes; I remember they were made by men under my charge, and I think the date in the book is correct—that they were delivered the 19th of March, 1879.

Q. 22. Do you know if these were put in use in connection with a dymnamo machine after they were made, and how soon after they were made.

A. Yes, they were put in use directly they were
312 finished.

Q. 23. Do you remember whether or not resistance coils were made before that date?

A. I think there were some made before that.

Q. 24. Do you remember how long before?

A. No. It must have been a short time though.

Cross-Examination by H. A. Seymour, Esq., Counsel for Brush:

x-Q. 25. While at work for Mr. Edison in 1878 and 1879, were you employed in the laboratory?

A. I was foreman of the mechanical department 313
in the machine shop, and of outside work.

x-Q. 26. You had nothing to do with the experiments, had you?

A. No.

x-Q. 27. And you were not concerned whether the experiments in the laboratory were successful or unsuccessful, were you?

A. No, sir.

x-Q. 28. Were the machine shops and the laboratory two separate and independent departments?

A. No. sir; they were not strictly separate nor in- 314
dependent.

x-Q. 29. Did you have charge of the force employed in the laboratory?

A. Only over part of the force.

x-Q. 30. Please give the names of the persons employed in the laboratory who were under your charge in the latter part of 1878 and spring of 1879?

A. In the latter part of 1878 the machine shop was in the same building with the laboratory and I
had charge of all hands except a very few. 315

x-Q. 31. Please give the names of the persons employed in the laboratory in February and March, 1879, who were under your charge and direction?

A. Louis Tweede, George Hill, George Carman. There were others whose names I don't remember.

x-Q. 32. Was Mr. Jehl, the witness who testified this morning, under your charge at that time?

A. He was under my charge the first two weeks
he was there. 316

x-Q. 33. Were the dynamo machines you have spoken of located and operated in the laboratory?

A. They were located in the laboratory until Christmas, 1878, after which time we moved into the new machine shop and placed them all there.

x-Q. 34. Who had charge of the dynamo machines after Christmas, 1878, at which time they were removed from the laboratory?

A. I had charge of them so far as the taking care

817 of them goes, but Mr. Upton and Mr. Edison used them in experimenting.

x-Q. 35. Did any other person besides Mr. Edison and Mr. Upton use the dynamo machines in the new machine shop for purposes of experiment?

A. Yes, sir; Mr. Batchelor and later on Mr. Jehl and Mr. Clarke.

x-Q. 36. How do you know that Mr. Edison had and used a dynamo electric machine about September, 1878?

318 A. I was there and saw them in use.

x-Q. 37. How many such machines were in the use at the time stated?

A. In September there was only one.

x-Q. 38. What make was this machine?

A. The Wallace.

x-Q. 39. A large or small Wallace machine?

A. In September, I think, we had the small?

x-Q. 40. What was the size of the small machine?

319 A. I think they called it about five or six horse power machine; I don't know the number of the machine.

x-Q. 41. How do you recall the fact that it was about September, 1878, that Mr. Edison first had this machine?

A. It was in August that Mr. Edison was in Ansonia at Mr. Wallace's works, and shortly after we received a machine from there.

820 x-Q. 42. How do you recall the fact that Mr. Edison was in Ansonia in August, 1878.

A. I remember that in July, 1878, he went to California, and two or three weeks after he began to experiment on electric light, and that he went up to see Mr. Wallace with Mr. Batchelor. They were away Saturday and Sunday and returned on Monday.

x-Q. 43. When was this small Wallace machine returned?

A. I think it was in November, 1878; perhaps the latter part of November.

x-Q. 44. When was the large Wallace machine received? 821

A. I think it was in October, 1878.

x-Q. 55. When was the Weston machine received?

A. I think about the latter part of October or first part of November, 1878.

x-Q. 56. When was the Gramme machine received?

A. In January, 1879.

x-Q. 57. What was done with the Weston machine?

A. We sold it to Mr. Bergmann, of 108 Wooster street, New York. 322

x-Q. 58. When was it sold and delivered?

A. It was, I believe, in the year 1880, but I do not remember the month.

x-Q. 59. What was done with the Weston machine while it was at Menlo Park?

A. It was very seldom used.

x-Q. 60. What do you mean by "very seldom?"

A. Three or four times during the whole time it was there. 323

x-Q. 61. For what purpose was it used?

A. For electric light experiments.

x-Q. 62. Was it used alone or in connection with one of the other machines?

A. To my knowledge always alone.

x-Q. 63. Were the other machines you have referred to as having been used at Menlo Park in the fall of 1878 and in 1879 used as dynamo or as magneto electric machines.

A. They were used both ways. 324

x-Q. 64. Why were they used both ways?

A. I can't answer this question exactly.

x-Q. 65. Why can't you answer this question?

A. Because I do not remember the experiments they were used in. It would shorten the whole thing to say I don't know.

x-Q. 66. Please explain how it came about that you had knowledge of the fact that these machines

325 were used in both ways; or had you no personal knowledge of that fact?

A. I have seen them used in both ways.

x-Q. 67. When they were used as magneto electric machines, how were their field of force magnets energized?

A. By using a battery or a dynamo machine for exciting the field.

x-Q. 68. When did you first see any of the machines used as magneto electric machines?

326 A. I don't remember the date; in was in the early part of 1879.

x-Q. 69. Are you positive it was prior to April, 1879?

A. Yes, sir.

x-Q. 70. When as dynamo machines?

A. The first part of 1879.

x-Q. 71. You have spoken of having machines of the Edison type. When did you first see one of such machines in operation and provided with a

327 variable resistance for regulating the strength of its field of force magnets?

A. I think it was in April, 1879.

x-Q. 72. Were its field of force magnets excited by another machine or by a battery.

A. I do not remember.

x-Q. 73. Who built this machine you saw in April, 1879?

A. We built it in our own shop.

x-Q. 74. Had it a vibrating or a rotating arma-

328 ture?

A. A rotating armature.

x-Q. 75. What was the construction of the device for exciting the field of force-magnets of a dynamo machine that you saw in December, 1878?

A. There was no particular device constructed for it. It was arranged with wires.

x-Q. 76. Please explain how it was arranged with wires, and how it was connected to effect the results specified.

A. Resistance was inserted in the fields and cut out, or more added, and so regulated. 329

x-Q. 77. Please describe the construction of the resistance and the circuits of the machine, clearly showing the location of the resistances; and whether one or two machines were used, or a battery employed.

A. I am not familiar enough with the way the connections were to make that explanation.

x-Q. 78. If you do not know how the connections were made, are you willing to swear positively that 330
this dynamo machine in question had the variable resistance located in the proper circuit to regulate the strength of the field of force-magnets?

A. I am not certain enough that I could swear that it was so, but to the best of my recollection it was so.

x-Q. 79. Still you are not certain on this point?

A. No.

x-Q. 80. You have referred to the month of December, 1878, as having seen something at that time. 331
By what incident is that particular month fixed in your memory?

A. I think it was at that time that Mr. Edison made some experiments with the electric light, day and night continuously, until his eyes were so sore that he had to stop, and at that time we used the magnet-spools that I spoke of before as used for such purposes.

x Q. 81. What makes you think it was in December, 1878? 332

A. I remember some of the work that was done about that time and which he used for experiments about the same time.

x-Q. 82. In so far as the use of adjustable resistances at Menlo Park is concerned, are you willing to swear positively that prior to April, 1879, such adjustable resistances were used in connection with dynamo or magneto-electric machines, to regulate the strength of their field of force magnets; or do you wish to be understood as testifying to the fact

333 that adjustable resistances were there employed, but their particular location and function you had no knowledge of?

A. I can positively swear that they have been used about the time above named for that purpose.

x-Q. 83. Then please give a detailed description of the construction of an adjustable resistance, and the different circuits of a dynamo or magneto-electric machine, with which it was connected, prior to April, 1879; and further specify the particular circuit in which the adjustable resistance was located?
334

A. The resistance coils were inserted in the line of the field magnet. I am not sure enough to describe the circuits. I am sure that I knew them; but it is so long ago that I have forgotten about it.

x-Q. 84. What were the ends of the line of the field magnets connected with?

A. I have had nothing to do with connections for so long that I feel uncertain about them.

x-Q. 85. Can you tell us the particular parts of
335 the machine with which the main circuit was connected?

A. No, sir.

x-Q. 86. Can you tell us how these connections are made in the machines of Mr. Edison, in use to-day. I mean the circuit of the field of force magnets, and the main circuit?

A. No, sir.

x-Q. 87. If you do not know to-day the connections of the different circuits of a dynamo-electric
336 machine, and are unable to testify as to the connections of the dynamo machines employed by Mr. Edison prior to April, 1879, I desire to know how you are enabled to swear positively, and if you are still positive that in the machines used at Menlo Park, prior to April, 1879, resistance coils were placed in the circuit of the field of force magnets?

A. I have seen it done, and at the moment I thought I could explain it. But now it has slipped my memory, and I can't explain it any more.

x-Q. 88. But the point is, how do you know it

was the circuit of the field of force magnets when 337
you can't describe the circuit? Are you positive in this matter?

A. I am not positive.

x-Q. 89. Were the resistance coils made in March, 1879, substituted for the spools and the zig-zag wires, because the wire of the latter burned up in use?

A. Yes; I think so.

x-Q. 90. You are not positive, are you, as to just how the adjustable resistances were used in connec- 338
tion with dynamo electric machines from early in 1879, up to to-day?

A. No; I am not so positive that I can explain it. I know how they were used, and have seen them in use daily, but cannot explain it.

x-Q. 91. Do you mean to be understood as saying, that you have seen adjustable resistances used in one of the circuits of, or connected with the dynamo machine, but that you are not positive which circuit did include such resistances? 339

A. Yes, sir.

x-Q. 92. Not being positive in this matter, you would not swear positively, would you, that the adjustable resistances served to regulate the strength of the field of force magnets?

A. I am aware that nothing else is used to-day, and nothing else was used but that, to regulate with; that outside of this, there is but one way, that is varying the speed, that would regulate it.
The first is done as being always performed. But 340
as I cannot explain the matter thoroughly, I do not want to swear it.

x-Q. 93. Were the resistance coils, delivered on March 19th, 1879, used for various purposes where a resistance was required?

A. As to that I do not know. I know that they were ordered for the purpose of regulating the electro motive force.

x-Q. 94. Are you positive that these coils were finished, or delivered on the 19th of March, 1879?

341 A. I would not have made the entry in the book if they had not been delivered then.

x-Q. 95. Do you know exactly when any of these coils were first used in connection with a dynamo machine?

A. No; I do not know the exact date, but I remember there was a great hurry for them, and they were used as soon as they could have them.

Cross-examination ended.

342 Mr. Keith declines to cross-examine the witness.

RE-DIRECT EXAMINATION, BY GEORGE W. DYER, COUNSEL FOR EDISON:

Re-d. Q. 96. You have testified that you were a mechanical foreman; have you ever professed to be an electrician?

A. No. sir.

Re-d. Q. 97. Do you remember the fact that Mr.
343 Upton came to Menlo Park?

A. Yes, sir.

Re-d. Q. 98. Was Mr. Edison experimenting on electric lamps before Mr. Upton came to Menlo Park.

A. I think he was.

Re-d. Q. 99. Was Mr. Edison using dynamo-electric machines before Mr. Upton came to Menlo Park?

A. Yes; I believe he was.

344 Re-d. Q. 100. Was Mr. Edison using dynamo-electric machines to supply a current to electric lamps before Mr. Upton came to Menlo Park?

A. Yes; Mr. Edison was using electric currents from dynamo machines before Mr. Upton came permanently to Menlo Park?

Re-d. Q. 101. Was Mr. Edison using means to regulate the current of dynamo machines, employed for electric lamps, before Mr. Upton came to Menlo Park?

Objected to as not properly re-direct examination of the witness.

A. I am not sure—I believe so. 345

Re-d. Q. 102. Was he, before Mr. Upton came permanently to Menlo Park?

A. I believe so.

Re-d. Q. 103. Immediately after Mr. Upton came permanently to Menlo Park, did Mr. Edison continue to employ dynamo-electric machines for furnishing a current to electric lights?

A. Yes, sir; I think he did.

Re-d. Q. 104. In such employment of the dynamo-electric machines, did he use an adjustable re- 346
sistance?

Objected to as not re-direct.

A. Yes, sir.

Re-d. Q. 105. What was the purpose of that adjustable resistance?

A. To vary the electro-motive force of the dynamo-electric machines.

Re-d. Q. 106. When you answered the numerous
questions, on cross-examination, that you did not 347
recollect the precise connections which were employed by Mr. Edison, with his dynamo machines, did you mean to imply that you had any doubt whatever of the use or purposes of use of the adjustable resistances employed by Mr. Edison in the fall of 1878, and the following winter and spring?

A. No, sir; I have not the slightest doubt.

RE-CROSS EXAMINATION BY H. A. SEYMOUR, ESQ., COUNSEL FOR BRUSH: 348

Re-x-Q. 107. When did Mr. Upton come to Menlo Park. Give the date?

A. I can't remember the date. I think it was in the fall of 1878, but I am not sure.

Re-x-Q. 108. Might it have been as early as September 1, 1878?

A. I don't think he came permanently to Menlo Park as early as September.

Re-x-Q. 109. Are you positive that he did not come as early as September, 1878?

349 A. No; I am not positive at all.

Re-x-Q. 110. When he came to Menlo Park did Mr. Upton have aught to do with your particular class of work?

A. He ordered some experimental apparatus to be made in the shop.

Re-x-Q. 111. Who ordered them before he came?

A. Mr. Batchelor or Mr. Edison.

Re-x-Q. 112. Is there any incident or fact by
which you can distinctly remember the fact of his
350 arrival at Menlo Park?

A. Not without reference to my note book.

RE-RE-DIRECT EXAMINATION BY GEO. W. DYER, COUNSEL FOR EDISON:

Re-re-d. Q. 113. Was not Mr. Upton's employ-
ment the first instance in which Mr. Edison had
called to his assistance a gentleman of exact scien-
tific information; and did not that fact make a
distinct impression among the employees at Menlo
351 Park?

Objected to as leading and as clearly and broadly suggesting the answer desired of the witness.

A. Yes, sir; it did.

RE-RE-CROSS BY MR. SEYMOUR:

Re-re-x. Q. 114. Please explain how the exact sci-
entific information reposed in Mr. Upton on and
prior to his arrival at Menlo Park, created this dis-
352 turbance or distinct impression among the Menlo
Park employees on the date of his arrival?

A. Mr. Upton had frequently been at Menlo Park previous to his permanently stopping there.

JOHN KRUESI.

By consent the taking of testimony was postponed to Thursday, November 10th, 1881, at same time and place.

WM. H. MEADOWCROFT,
Notary Public,
N. Y. Co.

Pursuant to adjournment, the taking of testi- 353
mony was continued on Thursday, November 10th,
1881, at same place, same parties being present.

FRANCIS R. UPTON, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows, in answer to questions proposed to him by George W. Dyer, counsel for Edison:

Q. 1. Please state your name, age, residence and occupation?

A. Francis R. Upton; age, 29; residence, Menlo
Park, N. J.; occupation, manufacturer of electric 354
lamps.

Q. 2. Have you been in the employment of Mr. Edison, and if so, from what time to what time, and in what capacity?

A. I entered his employ November 15th, 1878, and have been in it directly up to January, 1881, and indirectly since I was employed as a mathematician.

Q. 3. Please state what your education and train-
ing had been before you went into Mr. Edison's em- 355
ploy?

A. A college course at Bowdoin; two years post graduate study in physics at John C. Greene's scientific school at Princeton; and one year in Berlin, under Helmboltz, working in the physical laboratory there.

Q. 4. When you went into the employ of Mr.
Edison, on the 15th of November, 1878, did he there-
after immediately explain to you his system of elec-
tric lighting? 356

A. He did.

Q. 5. What explanation, if any, did he make with regard to dynamo electric machines and the most economical and efficient modes of use with his electric lights?

Objected to as leading.

A. He intended to have main lines leading out from stations charged with a constant electromotive force. He also recognized that this could be

357 done only by regulating the field of force on the machines, so as to give satisfactory results.

Q. 6. What do you mean by "field of force" in the preceding answer?

A. The magnetic influence of the iron forming the cores of the magnets upon the armature.

Q. 7. How did he propose to accomplish this regulating?

A. By means of varying the strength of the current flowing through the wire around the magnets.

358 Q. 8. How did he propose to vary the strength of the current?

A. By inserting resistance in the line of the magnets.

Q. 9. What kind of resistance?

A. Metallic.

Q. 10. I mean in regard to constancy.

A. One that could be varied at will; adjustable.

Q. 11. At the time you went there, November
15th, 1878, did Mr. Edison have any dynamo elec-
359 tric machines, if so, state of what general character
or name?

A. There was a large Wallace machine, a small Wallace and a small Weston plating machine.

Q. 12. Do you remember what became of the small Wallace?

A. My impression is, it was returned to Mr. Wallace; I know it was shipped away from Menlo Park.

Q. 13. Do you remember about what time that was, that it was shipped away?

360 A. December, '78, or January, '79.

Q. 14. Did Mr. Edison have a Gramme machine, and if so, at what time?

A. Yes; in January, '79; I think.

Q. 15. How soon after that machine was received was it put into actual use?

A. Very shortly after it was received.

Q. 16. What means, if any, were employed with that machine for primarily varying the strength of the current, exciting its field of force electro mag-

nets, whether by an adjustable resistance or other- 361
wise?

Objected to as leading.

A. The magnet coils were arranged so that the current passing through them could be varied by means of adjustable resistances.

Q. 18. I call you attention to the exhibits marked "Edison's Exhibits Nos. 2, 3 and 4," and ask if you recognize them?

A. I do.

Q. 19. Where did you first see them, and about 362
what time, as near as you can remember?

A. I saw them all in Mr. Edison's laboratory at Menlo Park; Exhibit No. 2, about the 1st of March, 1879; Exhibit Nos. 3 and 4 in the middle or latter part of March, 1879.

Q. 20. Were these put in use with a dynamo electric machine; if so, when; in what machine, and in what manner, and for what purpose?

Objected to as leading. 363

Q. 21. They were so put in use with the Gramme machine at the laboratory, and other machines, so as to form part of a circuit through the wire around the magnets for the purpose of regulating the current flowing through the magnets, immediately after the resistances were made?

Q. 22. What means, if any, was employed for adjusting the resistance at that time?

A. By inserting plugs between the binding posts
on top of the boxes, so as to short circuit the boxes, 364
and also by means of wires twisted around the binding posts or inserted in the binding posts to short circuit one or more boxes at a time; plugs were generally used.

Q. 23. Please examine the exhibits marked Edison's Exhibits 5, 6 and 7, and state whether or not you recognize them, and if so, when and where you first saw them, and what use, if any, was made of them?

365 A. I recognize them as part of the apparatus used at the laboratory at Menlo Park for regulating the current flowing around the magnets of the machines used for producing light. The upper portion of the apparatus, being Exhibit No. 5, was constructed earlier than the rest. I think that was made somewhere about September, 1879. Nos. 6 and 7 were put on afterwards for convenience a few weeks later.

Q. 24. What was the convenience referred to in
366 your previous answer?

A. A galvanometer, by means of which the strength of the current was noted, was on the table immediately under the table on which the resistances and Exhibit No. 5 were placed, and it was found convenient to turn the hand of Exhibit No. 5 by turning the wheel Exhibit No. 7 from the room below.

Q. 25. How long were these exhibits kept in position and used at Menlo Park in the manner de-
367 scribed by you?

A. They were in position up to within a few weeks and used whenever lighting was done at the Park from the machines in the laboratory.

Q. 26. Do you know whether or not adjustable resistances were used by Mr. Edison for regulating the strength of the current of the field of force magnets prior to the use of resistances like Edison's Exhibit No. 2?

A. Bobbins of wire were used and wire strung in
368 a frame.

Q. 27. I call your attention to the issues in this interferences printed in the record in question 10 in the testimony of Mr. Edison, and ask you at what point of time, to your knowledge, Mr. Edison had clearly in mind the inventions set out in these issues?

> Objected to, as Mr. Edison only is competent to testify as to what he had in his own mind, and the witness as to facts coming within his personal knowledge while at Menlo Park.

A. Judging from conversations that I had with him, I should say shortly after I entered his employ. 369

Q. 28. Has Mr. Edison to your knowledge since that time used, or proposed to use, in connection with dynamo-electric machines, any system other than that set out in the issues of this interference.

> Objected to on the ground that it has not been shown that the witness comprehends the subject matter comprised by the two issues of this interference, or that he understands the scope of these issues. 370

A. Though other systems may have been discussed and experiments tried on them, the system in the first part of the issue has always been considered by Mr. Edison the best, so much so that one might almost say it is the only system which he has considered. The second issue, his practice has always been to use the means there described for regulating the current applied to the magnets, though other methods are known and experiments have been tried with other methods. 371

Q. 29. To your knowledge how constant has been the use by Mr. Edison of means applicable to these issues?

A. Ever since the resistance coils in Edison's Exhibits 2 have been made they have been in constant use for the purposes set forth in this issue to this time.

> Mr. Gordon on behalf of Mr. Keith adopts Mr. Seymour's cross-examination of all the witnesses, and waives the further cross-examination of any witness. 372

Cross-examination by H. A. Seymour, Counsel for Brush:

> Counsel for Brush here introduces in evidence certified copy of the specification and drawing of the application of Thomas A. Edison, filed May 31st, 1880, for Magneto or Dynamo-Electric Machines, which is desig-

373 nated as "Brush Exhibit, Edison Application."

x-Q. 30. I now hand you "Brush Exhibit, Edison Application," and inform you that this is a true copy of Edison's application in this interference, and on which the issues of this interference are founded. Please examine it and state if you understand it?

A. I think I do.

x-Q. 31. The second claim of this application
374 reads as follows: "A magneto or dynamo electric machine constructed or combined with suitable device for primarily varying the strength of the current exciting its field of force magnets." Referring now to the specification and drawings, what do you understand is referred to by the words "suitable device."

A. In figure 1 the combination of the source of electricity, G, with the resistances, H, which by
375 means of the commutator, K, may be thrown in or out of the circuit of which the wire around the magnets *f* form a part. In figure 2 the combination of the resistances, H, with the source of electricity, F', together with the means, K, by which more or less of the resistance, H, may be put in circuit with the wire, on the magnets of the machines, F', *c*, *c*, *c*, *c* and *c'*.

x-Q. 32. In other words the "suitable device" in question, shown in figure 1 and referred to in that portion of the specification relating to this figure,
376 consists of a battery G, and an adjustable resistance H, K, located in the circuit of the magnets of a magneto machine. Is not this your understanding?

A. Except that any source of electricity may be used at G for primarily exciting the magnets *f* of the machine F, yes.

x-Q. 33. Now, in the drawing, figure 2 which relates to the dynamo machine, and in that portion of the specification referring to this figure, the "suitable device" in question consists of the dyn-

amo machine F', its main circuit 8, 8, and adjust- 377
able resistance K, does it not?

A. Yes.

x-Q. 34. How does the third claim differ from the second. Do not both claims refer to certain means that you have specified in your late answers for accomplishing the desired results?

A. The second claim seems to me the broader of the two, in that a suitable device for primarily varying the strength of the current exciting its field
of force magnets is mentioned, while in the third 378
the combination with one or more of its inducing field of force magnets, with an adjustable resistance, is mentioned. Both claims refer to a certain means of regulating the field of force.

x-Q. 35. The words "suitable device," in the second claim, comprehend the "field of force magnets" and "adjustable resistance" specified in the third claim, do they not?

A. I think they do.

x-Q. 36. Then both the second and third claims 379
refer to the same means, do they not, and the difference is that the second claim refers to the means necessary to accomplish the result, while only a portion of the means necessary to that end are specified in the third claim. Is not this correct?

Objected to on the ground that the witness is not testifying as an expert in patent matters, and that the claims themselves are the best evidence of what they cover.

Counsel for Brush states that the witness 380
at the outset qualified in a manner tending to show his ability to testify as an expert in electrical matters, and that he has repeatedly testified concerning inventions specified in the issues, and hence must have understood or supposed that he understood the scope of the issues, and if he can comprehend the issues he certainly can the claims in question, as they are nearly of the same language.

381 A. In so far as the means are mentioned the question is substantially correct.

x-Q. 37. In the Edison application, do you find therein shown, described or suggested, a dynamo machine adapted to excite its own field of force magnets, provided with a device for regulating the strength of its field of force magnets?

A. I do.

x-Q. 38. And this device is located in the main circuit of the machine, is it not?

382 A. It is in the main circuit of the machine so far as shown in the drawing.

x-Q. 39. How long were you employed exclusively as mathematician for Mr. Edison?

A. Till January, 1881. The mathematics was largely of the applied sort.

x-Q. 40. Please explain your particular duties in this position?

A. My first duty was to make such calculations as Mr. Edison needed, if it were in my power. When
383 there were no calculations to be made I employed my time as he thought would be most useful to him.

x-Q. 41. You have stated that Mr. Edison explained to you his systems of electric lighting and dynamo electric machines when you first entered his employ. How many dynamo machines did he explain to you at that time?

A. His explanations were more of the nature of telling the use he had proposed making of a dy-
384 namo electric machine than descriptions of particular machines, for I had a chance to examine the machines themselves, and also to read the literature of machines, so that I do not think he felt called upon to give me details that I was supposed to know.

x-Q. 42. Will you please state how many dynamo machines were at Menlo Park when you entered his employ, the 15th of November, '78, and the different types of machines then in practical use?

A. There was at or about that time a large Wal- 385
lace, a small Wallace and a Weston machine.

x-Q. 43. Was this all?

A. There was a large number of small magneto and experimental machines of Mr. Edison.

x-Q. 44. When did you first see a dynamo machine of Mr. Edison's make put into practical operation and having combined therewith an adjustable resistance for varying the strength of its field of force magnets?

A. To the best of my recollection it was in March, 386
1879.

x-Q. 45. Would you swear that it was prior to April, 1879?

A. Not without going over the records.

x-Q. 46. With this machine, what construction of adjustable resistance was used?

A. The resistance boxes shown in Exhibits 2, 3 and 4 were used.

x-Q. 47. Were they located in a circuit of a bat-
tery, including the field of force magnets? 387

A. They were coupled as is represented in figure 1 of the drawing of the application in interference.

x-Q. 48. That is the field of force was excited by a battery?

A. I think both batteries and dynamo machines were used.

x-Q. 49. When did you first see the Gramme machine operated in connection with a variable resistance for regulating the strength of the main cur-
rent? 388

A. In March, 1879.

x-Q. 50. Are you willing to swear that it was prior to April, 1879.

A. I have examined the records of the laboratory and every date points to the fact that it was prior to April.

x-Q. 51. How does the record point to such fact?

A. The date of Mr. Jehl's coming to the laboratory fixes the time that the resistances were being made, as the first week in March, and my recollec-

889 tion is that they were used immediately after they were finished in connection with the machines, and I know we were in a great hurry to finish them.

x-Q. 52. Were these resistance boxes used to test the machines? If so, what machines, and to test them for what purpose?

A. They were used first in the Gramme machine and then on Mr. Edison's machines to test their efficiency.

x-Q. 53. And how did you test their efficiency by
890 the use of these resistance boxes?

A. The strength of the current around the magnets was varied and the effects noticed.

x-Q. 54. Why did the strength of the current vary, and why were the effects noticed?

A. To gain information regarding the efficiency of the machines.

x-Q. 55. What do you mean by "efficiency"?

A. Their power to convert energy of motion into electrical energy, taking into consideration their
891 mechanical construction.

x-Q. 56. Then the resistance boxes were used to experiment and determine the strength of current that could be produced by the machine, were they?

A. Yes.

x-Q. 57. When did you first see either of the Wallace machines and an adjustable resistance connected therewith in operation? I mean to regulate the strength of the field of force magnets.

A. I do not recollect the Wallace machine in
892 connection with a variable resistance.

x-Q. 58. When did you first see the Weston machine in operation having a variable resistance connected therewith for regulating the strength of its field of force magnets?

A. I have no means of fixing this date as we used simply a length of wire when we tried this machine in this manner.

x-Q. 59. This machine did not operate satisfactorily, did it?

A. It was of too low electro-motive force to be of

great use, though the principle was demonstrated 393
the same.

x-Q. 60. Was it of any practical use?

A. Yes, for plating, heating rods of carbon, and for experimental purposes. The same machine is now in use for magnetizing.

x-Q. 61. I mean was it found to be of any practical use for the purposes desired by Mr. Edison?

A. It is not a desirable machine for incandescent lighting, since we require a high tension machine.

x-Q. 62. From the time you entered Mr. Edison's 394
employ, how long were various types of electric lamps used and experimented with that were each provided with devices for regulating the flow of the current to their carbons or burners?

A. Up to within three months such devices have been made.

x-Q. 63. And up to the summer of 1879 all of the lamps were provided with independent devices for regulating the flow of current to their carbons or burners, were they not? 395

A. By no means. We were experimenting on devices and using lamps without them.

By consent the taking of further testimony was postponed to Friday, November 11th, 1881, at 10 o'clock A. M., at same place.

Wm. H. Meadowcroft,
Notary Public,
New York Co.

396

Pursuant to adjournment, the taking of testimony was continued on Friday, November 11th, 1881.

Present—N. S. Keith, in person; Richard N. Dyer, of counsel for Edison, and H. A. Seymour, of counsel for Brush.

x-Q. 64. Have you made quite a careful research and investigation of the prior state of the art to ascertain the character of devices and instruments

397 employed for the application of electricity to practical purposes.

A. I made a careful research concerning electric lamps and read the current literature concerning dynamo machines.

x-Q. 65. You found that adjustable metallic resistances were very old and well known devices for testing the strength of an electric current, did you not?

A. Yes.

398 x-Q. 66. And you also found that adjustable metallic resistances were very old and well known devices for regulating the strength of the current, did you not?

A. Yes.

x-Q. 67. And you found that adjustable metallic resistances for the purposes above stated were old and well known long prior to 1870, did you not?

A. Yes.

x Q. 68. From your knowledge of the state of the
399 art, prior to your entering Mr. Edison's employ, if you had desired to regulate or test the strength of an electric current, you would have employed an adjustable metallic resistance for that purpose, would you not?

A. In many instances.

x-Q. 69. And in so doing you would have considered that you had simply employed a well known device for a well known purpose, would you not?

A. The device would have been old, the pur-
400 pose new or old, according to the occasion.

x-Q. 70. If the purpose had been to regulate or test the strength of the current, it would have been an old and well known purpose, would it not?

A. By no means.

x-Q. 71. Why not?

A. For example, if a new method of testing electro-motive force of batteries were devised, adjustable metallic resistances would have been used in all probability, while the combinations would be new, as in electricity three factors alone enter into all ex-

periments. These factors are electro-motive force, 401
current and resistance. And as the latter is generally in a metallic form, nearly every experiment requires its use. The novelty of its use would depend entirely upon the experiment tried and the form in which the resistance is made.

x-Q. 72. You seem to misunderstand my question. I did not wish to imply that at the time you entered Mr. Edison's employ the door to further discoveries in electrical science had been closed, but desire to know this: If at the time stated that you had 402
employed an adjustable resistance to regulate or test the strength of an electric current, you would have simply resorted to a well known device for this purpose which had been in use for a period of many years prior to this time.

A. Yes; but the form of resistance used could be new.

x-Q. 73. In your investigations you found that long prior to your entering Mr. Edison's employ it was very old and well known to employ an adjust- 403
able resistance in an electric circuit including an electro-magnet, one or more, did you not?

A. Yes.

x-Q. 74. And you ascertained to your satisfaction that this had been done long prior to 1870, did you not?

A. Yes.

x-Q. 75. And in such case the strength of the electro-magnet was varied by regulating the adjustment of the variable resistance, was it not? 404

A. There must have been many instances where such was the case.

x-Q. 76. Long prior to your entering Mr. Edison's employ adjustable resistances consisting of wire wound about a spool had been used, had they not?

A. Yes.

x-Q. 76. And such forms of adjustable resistances had been known for a great many years as suitable devices in regulating or testing the strength of an electric current, had they not?

405 A. Yes.

x-Q. 77. What construction of adjustable resistance was first used in connection with the Gramme machine, which you have referred to in the testimony?

A. I think flattened copper wires strung on a frame lengthwise between the two sides.

x-Q. 78. For what purpose was this adjustable resistance used?

A. For regulating the strength of the current
406 from the machine.

x-Q. 79. How was it used? In the circuit of a battery?

A. I cannot say whether this particular form was used with a battery.

x-Q. 80. Was it used to regulate and control the strength of the current of the main circuit, or to test the efficiency or capacity of the machine?

A. I cannot say regarding this particular form of resistance.

407 x-Q. 81. Do you remember that the form of resistance you have referred to was discarded because the wires burned out?

A. That was probably the reason, and also that we made better forms afterwards.

x-Q. 82. When did you first see an adjustable resistance substantially like either one shown in Edison's application used in connection with a dynamo-machine?

A. In March, 1879, though there may have been one
408 of Mr. Edison's machines tested in February in this way, as I find dates in the note books about the first of March and the latter part of February.

x-Q. 83. In the apparatus you refer to as having seen in March, 1879, how many of the resistance boxes were used at one time in connection with the machine?

A. Our custom was to place a large number of the boxes in the circuit we were experimenting on, and so as to have them ready for any adjustment

that we might wish to make, for by putting in a 409
plug any box could be made idle.

x-Q. 84. They were used, then, in order to secure such strength of current as might be desired for the particular experiment in hand, were they?

A. Certainly; either directly or indirectly?

x-Q. 85. Were they located in a circuit of a battery, including the field of force magnets of a machine, or in the main circuit of one machine including the field magnets of another machine?

A. Sometimes in one way and sometimes in the
other. 410

x-Q. 86. Were they used in any other way at the time stated, except the two methods referred to by you?

A. In all probability they were, as Mr. Edison was trying, after his usual manner, various combinations.

x-Q. 87. I do not care to know about probabilities, but simply desire your testimony concerning facts within your personal knowledge. Please answer 411
the question with this understanding.

A. I should have to make further search, before fixing the date of other uses as positively as I have fixed the date of the two mentioned, for I recollect the two first distinctly, and know that other uses were made, either at the same time or shortly after.

x-Q. 88. Is Edison's Exhibit No. 2 an adjustable resistance?

A. I took the exhibit to be a specimen of a number of boxes, which as a whole, were adjustable. 412

x-Q. 89. Long prior to your entering Mr. Edison's employ, it was old to excite the field of force magnets of one dynamo machine by means of another dynamo machine, was it not?

A. It was to excite the field of one dynamo by a magneto machine, as for instance, in the Wilde machine. I do not recollect any dynamo, though it could easily be found from the text books whether it was so.

x-Q. 90. And it was old prior to your entering

413 Mr. Edison's employ, to vary the strength of the field of force magnets of a dynamo machine by varying the strength of the current, produced by a separate magneto machine connected with the dynamo, was it not?

A. I have no instance in mind. This is a matter of outside record. I know of cases where it has been done recently.

x-Q. 91. But do you not recall the fact that it was old to do this, although you are at present un-
414 able to fix upon any particular instance?

A. I could easily answer this question by reference to publications of about that date. I recall the fact of instances where this has been done, but not of dates.

x-Q. 92. When did you first see Edison's Exhibit No. 5, in use?

A. It was in use immediately after it was made—about September, 1879.

x-Q. 93. How was it used, state fully?

415 A. It was used regularly, as in figure 2 of Edison's application, being represented at K. The machine c′, being omitted in the circuit.

x-Q. 94. In September, 1879, are you positive that it was used in the main circuit of one dynamo machine, having the field of force magnets of a number of magneto machines included in its main circuit as in figure 2?

A. I think, when it was first put up it was used with one machine exciting its own field, in the cir-
416 cuit of the field. Afterward it was used in the direct circuit of one machine, exciting the field of one or more magneto machines. The latter arrangement we preferred, for the reason that the magnet circuit was independent of the main circuit, and not influenced by any fluctuation in the main circuit, though with care used in watching the fluctuations one method was as good as the other.

x-Q. 95. When did you first see it used in the manner you have first described: and when did you first see it used in the manner last described?

A. When it was first put in position I think it was used with one machine, and it may have been 417
used in the other way within a week, and the connections were changed to the machines according to the use that was being made of them. One way we term running the machine making its own field; the other, having its field made for it.

x-Q. 96. Describe the circuits and the location of the adjustable resistance, when the machine made its own field, as you have described?

A. One end of the magnet wire was connected directly to the brush of the machine, the other end 418
was connected through an adjustable resistance to the other brush of the machine.

x-Q. 97. In September, 1879, was there at Menlo Park a battery consisting of a number of machines and a separate dynamo for exciting their field of force magnets, as shown in Fgure 2 of Edison's application?

A. At that time there was one machine excited by another. Two machines were run at a later day. 419

x-Q. 98. Prior to your entering Mr. Edison's employ was it old to place adjustable resistance in the main circuit of a dynamo machine for regulating the strength of the current, as for instance, where the current was used for electro-plating or other purposes?

A. I can answer this question by reference to publications only.

x-Q. 99. Do you remember or know that this was done prior to the time stated, but simply fail to re- 420
collect the particular instance or the particular date that it was done?

A. I know that this has been done, but whether it was prior or since the time stated, I cannot say certainly; personally, I never saw it done.

x-Q. 100. As you say that you know it has been done, please give us your best impressions and belief as to whether or not it was done prior to your entering Mr. Edison's employ?

421 A. All that I know regarding the matter outside of Mr. Edison's laboratory has been gained from books and periodicals; I do not recollect at this moment any such use prior to my going to Menlo Park which was published at the time.

x-Q. 101. In your testimony have you considered that the first issue comprises devices and things not comprised by the second issue?

A. I consider that the first issue is the broader of the two and contains the second, except that the
422 second speaks of the combination with one or more of the inducing or field of force electro-magnets of an adjustable resistance, while in the first issue other devices than an adjustable resistance for "primarily varying the strength of the current exciting the field of force electro magnets," could be included.

x Q. 102. In your testimony what other devices than the adjustable resistance, have you had in mind that you consider as being included in the first
423 issue?

A. For example, changing the speed of the revolving armature, changing the position of the brushes may be covered in the first issue.

x-Q. 103. State when you first saw at Menlo Park the particular invention referred to in the second issue, that is, "In a dynamo-electric machine, the combination with one or more of its inducing or field of force electro-magnets of an adjustable resistance, whereby the strength of the current applied to said
424 magnets may be determined and governed and varied."

A. In March, 1879.

x-Q. 104. Will you swear that the machine was used as a dynamo, or was it used as a magneto?

A. The machine was used as a dynamo.

x-Q. 105. What machine was it and was it used singly and without a battery?

A. It was the Gramme machine and it was used singly at times and with a battery at times.

x-Q. 106. Was the adjustable resistance used for

the purpose of testing the strength of the current produced by the machine. 425

A. It was used for determining, governing and varying the strength of the current applied to the magnets.

x-Q. 107. Question repeated?

A. Some of the time.

x-Q. 108. Would it be possible to use a dynamo machine for any purpose without employing the means which you have considered in testimony as being covered by the first clause of the issue.

A. Yes; they are ordinarily so employed. 426

x-Q. 109. Are the devices or substantially the devices referred to in the issue in this interference, of vital importance to Mr. Edison's system of electric lighting?

A. They are important, for he uses them in connection with his lighting to-day. Whether they are vital or not, the future only can tell.

x-Q. 110. We are speaking of the present and past only. Please answer the question under such usual limitations. 427

A. I have not considered the whole bearing of the question enough to state whether it is vital or not.

x-Q. 111. If you are in doubt as to its being of vital importance, I desire to know if it is not considered a most valuable and important feature of his system of electric lighting?

A. In the broadest aspect of the case, yes.

Cross-examination ended.

Re-direct Examination by Richard N. Dyer, Esq., of Counsel for Edison: 428

Re-d. Q. 112. Referring to question 36 of your cross-examination and to the third claim of Mr. Edison's application in this interference, are not all the devices necessary for accomplishing the object of the combination of the third claim set forth in said claim?

A. Yes.

Re-d. Q. 113. Is it not a fact that the Gramme and

429 Weston machines which you have testified were used with the devices included in the issues of this interference, were practical working machines for the purposes for which they were built and not experimental machines?

A. They were and were used as such.

Re-d. Q. 114. Were not such machines used practically with said regulating devices for regulating the strength of the current generated, for the purpose of testing lamps and other translating devices?

430 A. They were.

Re-d. Q. 115. Do you know of your own knowledge that the subject matter in controversy was used by any other person than Mr. Edison before you entered his employ?

A. I do not.

FRANCIS R. UPTON.

JOHN F. OTT, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in an-
431 swer to questions proposed to him by Richard N. Dyer, of counsel for Edison:

Q. 1. Please state your name, age, residence and occupation?

A. John F. Ott; 134 Prospect street, Newark; age 31; occupation, experimenting for T. A. Edison.

Q. 2. State when you entered Mr. Edison's employ and in what capacity?

A. May the 9th, 1878; I was employed in the machine shop.

432 Q. 3. Have you been employed by him continuously since that time?

A. Yes, sir.

Q. 4. Were you acquainted with Mr. Edison's methods of operating and regulating dynamo and magneto-electric machines in the fall and winter of 1878?

Objected to as the witness has not yet testified that Mr. Edison operated and regulated any such machines at the time stated.

A. Yes, sir.

Q. 5. What method was used by him at that time 433
for regulating the generative capacity of such machines, and what was the character of the machines so regulated?

A. By putting in variable resistance in the field magnet, so as to take only a portion of the current from the main through the field magnet.

Q. 6. Do I understand that this variable resistance was in the circuit of the field magnet?

A. Yes, sir; it was.

Q. 7. When did you first see Mr. Edison regulate 434
a machine in this manner, and what was the character of the machine?

A. It was some time in the fall of 1878; the machine used was a Wallace machine.

Q. 8. Do you know when that machine was received at Menlo Park?

A. That date I do not remember; it was in the fall of '78.

Q. 9. How long after the Wallace machine ar- 435
rived at Menlo Park was the strength of its field varied by an adjustable resistance, according to the best of your recollection?

A. To the best of my recollection it was from three to four weeks after its arrival.

Q. 10. Calling your attention to sketches "Edison's Exhibit No. 9," was the Wallace machine at that time connected with a variable resistance in the manner shown in said sketches.

Objected to as leading. 436

A. It was exactly the same.

Q. 11. Do you understand those connections; if so, please explain them briefly?

A. In Figure 1 they are arranged so as to make one side of the Wallace machine a dynamo, charging the field of the other, with variable resistance in circuit, thereby varying the strength of the current of the other half of the machine.

Figure 2 is connected with a variable resistance in

437 the circuit of both field magnets, thereby being able to vary the current in the main line.

Q. 12. How is the current in the main line varied in this way?

A. By throwing in or out resistance, as may be required in the circuit of the field magnet.

Q. 13. What opportunities had you at that time for obtaining accurate information as to the means employed for regulating this Wallace machine?

A. By being employed by T. A. Edison and help-
438 ing him to set up the machine, and winding the resistance spools and boards and boxes as they might be called to be put in the circuit of the field magnet.

Q. 14. What was the construction of the resistances used to vary the field of the Wallace machine at that time.

A. One was a flat board, having nails driven into it and winding the wire back and forth; the other was a board having spools placed on it, connected up
439 so that any number of resistances may be connected in; the other was a Wheatstone rheostat; there was another one, a square box, wound with wire, the same shape as Exhibit 2.

Q. 15. How was the resistance varied in the cases of the first two constructions described by you?

A. By plugging in and out with a plug switch.

Q. 16. For what purpose was the Wallace machine, regulated in this manner, used in the fall of 1878?

A. Electric lighting.

440 Q. 17. With what other machine did Mr. Edison, to your knowledge, next use this method of regulation and at what time.

A. A Gramme machine, a few days after he received the Gramme machine, as I remember.

Q. 18. Can you not state about what time this Gramme machine was received at Menlo Park?

A. I can't state positively.

Q. 19. Do you recollect that it was before the employment of Francis Jehl?

Objected to as leading.

A. I couldn't say.

Q. 20. Do you recollect the year? 441

A. Yes; it was in 1879.

Q. 21. And what season of the year?

A. I cannot remember when it was received.

Q. 22. What was the character of the resistance employed with the Gramme machine.

A. Such as Exhibits 2, 3 and 4.

Q. 23. Please examine the exhibits marked "Edison's Exhibits 5, 6 and 7," state whether or not you recognize them, and if so when and where you first
saw them, and what use, if any, was made of them? 442

A. I first saw them in November, 1879, and they are the fac similies of those I saw then, if not the same. They were used to throw in and out resistance in the field magnet to vary the current on the main by increasing and decreasing the electric field.

Q. 24. How do you fix this date as November, 1879?

A. As it was shortly before the exhibition given 443
by T. A. Edison.

Q. 25. To what exhibition do you refer?

A. It was the exhibition of his new light.

Q. 26. At what time?

A. It was given between the holidays in 1879.

Q. 27. Do you recollect that you saw the Gramme machine used with the variable resistance to regulate the strength of its field before Exhibits 5, 6 and 7 were put in operation?

A. Yes, sir; I did. 444

Q. 28. About how long before, should you judge?

A. As far as I can remember at least two months?

Q. 29. With what machine or machines, and in what manner was the apparatus of which Exhibits 5, 6 and 7 formed a part, used in November, 1879?

A. They were rigged with the Gramme machine, I believe, first. They were arranged so as to vary the resistance in the circuit of the field magnet.

445 By consent the taking of further testimony was continued to Saturday, November 12th, 1881, at ten o'clock A. M.

WILLIAM H. MEADOWCROFT,
Notary Public,
N. Y. Co.

Pursuant to adjournment the taking of testimony was continued on Saturday, November 12th, 1881,
446 at ten o'clock A. M., same parties being present.

CROSS-EXAMINATION BY H. A. SEYMOUR, ESQ., OF COUNSEL FOR BRUSH:

x-Q. 30. What is your trade?

A. Mathematical and astronomical instrument maker. That's what I served at.

x-Q. 31. In what capacity did you enter Mr. Edison's employ—as a machinist?

A. As a machinist and in the laboratory experi-
447 menting. I entered first under Mr. Edison's instructions to experiment on the toy phonograph for Charles B. Harris.

x-Q. 32. Did your experimenting consist in making any particular device or thing ordered by Mr. Edison, or had you general orders to go on and perfect the phonograph?

Objected to as not bearing upon the issue in controversy.

448 A. I had general orders.

x-Q. 33. General orders of what kind?

A. By Mr. Harris and also by Mr. Edison.

x-Q. 34. General orders to do what?

A. To perfect the phonograph. If I found anything that I thought would work, to consult Mr. Edison.

x-Q 35. How long were you engaged in your experiments on the phonograph, and what class of work were you next engaged in?

A. From the 9th of May, 1878, until September, 1878; I was next engaged in making electric lamps.

x-Q 36. In September, 1878, did you work in the laboratory? 449

A. I worked both in the laboratory and machine shop.

x-Q. 37. How long did you continue to work in both the laboratory and machine shop on electric lamps?

A. I worked on the whole electric lighting system from September, 1878, until February, 1881.

x-Q. 38. In September, 1878, how many dynamo machines were at Menlo Park?

A. I couldn't exactly tell, as there were so many 450
of them.

x-Q. 39. I mean practical operative machines that were used?

A. They were all used with more or less results.

x-Q. 40. What do you mean by "more or less results"?

A. Some giving off a higher efficiency than others.

x-Q. 41. Well, were there as many as twenty dynamo machines then in use?

A. As I said before, I couldn't state the exact 451
number.

x-Q. 42. Give your best impressions as to the number of practical and operative dynamo machines in use at Menlo Park in the month of September, 1878?

A. That selected was the Wallace.

x-Q. 43. Question repeated.

A. They were all tried one after another. I 452
couldn't state the number, as I was not always present when the experiments were tried, as I had other work to attend to as well.

x-Q. 44. What do you mean by "all," one machine or fifty machines? Or about how many, to the best of your belief and recollection?

A. There were six or eight to my knowledge.

x-Q. 45. You may describe the different types of machines if there were six or eight, and how many of each type?

453 A. They were experimental machines of different styles of armatures and field magnets.

x-Q. 46. How many of these machines were of the Wallace type?

A. Two.

x-Q. 47. Was one of the Wallace machines in use in 1878, a large machine and the other a small machine?

A. They were large and small.

x-Q. 48. Now you have described one type and
454 accounted for two machines, please describe the other types used in September, 1878, at Menlo Park?

A. I think the other machine was a Weston. The balance were experimental machines made by Edison.

x-Q. 49. How many of the Edison type of machines constituted the balance you speak of?

A. That number I couldn't state exactly.

x-Q. 50. State as nearly as you can?

A. There was at least four or five.

455 x-Q. 51. And the Edison type operated satisfactorily, did they, at that time?

A. That was determined by himself and his assistants. I did not hear the results.

x-Q. 52. Were you one of his assistants at the time?

A. I was only a machinist really. I acted as an assistant when they needed me.

x-Q. 53. Did he need you as an assistant at
456 that time, and did you act in such capacity?

A. I did.

x-Q. 54. If it were known to Mr. Edison and his assistants whether or not the Edison type of machines worked satisfactorily at that time, please state the facts in the case, whether or not they did operate satisfactorily?

A. They were not known to me, they were known to his other assistants.

x-Q. 55. Can you account for the fact that in common with the other assistants you knew how the Wallace and Weston machines operated, but did

not know how the Edison machines operated at that time? 457

A. It wasn't made known to me. I heard from the other assistants that a new channel had been struck in constructing dynamos, or generators as they were called.

x-Q. 56. In the fall of '78 and spring of '79, were the machines used at Menlo Park for generating the main current for electric lights, operated as dynamo or magneto-electric machines?

A. They were magneto-electric machines, generally
known by the name of generator, to distinguish 458
them from dynamo machines.

x-Q. 58. In the fall of 1878 and spring and summer of '79, were variable resistances employed in connection with the magneto-electric machines for other purposes than to test the efficiency or capacity of the machines?

A. There was variable resistance used in the circuit of the field magnet.

x-Q. 59. Question repeated.

A. That I do not know; they were only used for 459
electric lighting, that I know of.

x-Q. 60. I am not speaking of the purpose of the current of electricity generated by the machines, but desire to know if, during the time stated, the variable resistances were used for other purposes than to test the capacity or efficiency of the machines with which they were employed?

A. As far as I know they were used for regulating
the field of an electro-magnet. 460

x-Q. 61. Were they used to regulate the field of an electro-magnet in order to produce any desired strength of current for testing electric lamps?

A. They were.

x-Q. 62. Were the variable resistances used for any other purpose that you know of?

A. Not that I know of.

x-Q. 63. At what time did you first see in use at Menlo Park, a variable resistance substantially like the form shown in Figures 1 and 2 of Edison's

461 Application, employed in connection with a dynamo
or magneto-electric machine?

A. It was in the early part of the fall of 1878, to
the best of my recollection.

x-Q. 64. Do you mean to say that in the fall of
1878 you saw a variable resistance provided with a
commutator, as shown in Figure 1.

A. Not exactly the same as there, but on that
principle.

x-Q. 65. I do not refer to the principle of operation,
462 but to matters of arrangement and construction of
variable resistances. With this understanding on
your part, I repeat my former question.

A. I did see it.

x-Q. 66. Do you mean to say you saw, in the fall
of 1878, a variable resistance provided with a commutator, as shown in Figure 1?

A. I saw a variable resistance connected up in
such a form that by pulling plugs, or as generally
known as "plug switch," the resistance could be
463 varied.

x-Q. 67. The form of variable resistance you have
last described is like that shown in Edison's Exhibit
No. 2, is it not?

A. The plugs are on that principle, as on the spool
"Exhibit No. 2." The resistances were wound in
different forms.

x-Q. 68. How do you know it was in the fall of
1878 that you first saw this form of variable resistance?

464 A. Because I had finished my experiments for
Charles B. Harris.

x-Q. 69. When did you finish them?

A. It was the latter part of August or the first
part of September, 1878.

x.Q. 70. How was Edison's Exhibit No. 5 employed when you first saw it in use?

A. It was put up in the laboratory, having four
wires or two distinct lines to the dynamo room or
work shop, connecting the resistance with one end
of the line to the dynamo room through the field

magnet, and back again, where it was connected to 465
the main line. Each resistance being connected
with one of the plugs of the circular rheotome, the
centre arm or lever being connected to the other
pole of the main line.

x-Q. 71. Were Edison's Exhibits 6 and 7 used in
connection with Exhibit 5 at that time?

A. It was; the long rods being used so as to get
the resistance as far away as possible from the Sir
William Thompson galvanometer, as it would have
an influence upon its deflection.

x-Q. 72. Could Exhibit 5 have been put into use 466
at Menlo Park in 1879 without your having knowledge of it?

A. It could; yes.

x-Q. 73. Did the variable resistances first employed at Menlo Park burn out and prove to be
practical failures?

A. They did not; they got extremely warm.

x-Q. 74. But no particular fault was found with
them by reason of their burning out or becoming
too highly heated; is that what you mean? 467

A. Not as far as the principle was concerned.

x Q. 75. You say you remember the exhibition in
the fall of 1879, because it was the exhibition of his
new light? What do you mean by "new light?"

A. Of his new system of lighting up.

x-Q. 76. What do you mean by "new system?"

A. Of his new form of lamp.

x-Q. 77. What was the new form of lamp?

A. Showing that the sub-division was practical; 468
that you may be able to throw in any new number
of lights without showing any practical difference
in the lights.

x-Q. 78. Do you mean that this exhibition was to
show a new subdivision of the current for old
lamps, or to show an old subdivision of current with
new lamps, or was it to show a new subdivision of
the current with new lamps?

A It was the old subdivision with any lamp—
either platinum or carbon.

469 x-Q. 79. Then what was there new exhibited at that time; or, in other words, will you state what you meant by "new lamp."

A. What I meant by "new lamp" was the subdivision.

x-Q. 80. Well, if you meant "new subdivision" instead of "new lamp," what was the "new subdivision" publicly exhibited at that time?

A. It was showing variable resistance in the circuit of the field magnet.

470 Cross-examination ended.

RE-DIRECT EXAMINATION BY RICHARD N. DYER, OF COUNSEL FOR EDISON:

Re-d. Q. 81. Were the Wallace and Weston machines among the "experimental machines" referred to in your answer to cross-interrogatory 45?

A. The Wallace was.

R-d. Q. 82. How was this an experimental machine?

471 A. It was used as an experimental machine; that's all.

R-d. Q. 82. The machine itself, then, was not an experimental machine, but was used practically to experiment upon lamps and other devices?

A. Yes, it was.

Re-d. Q. 83. And in this practical use the field was regulated by a variable resistance, was it not, in the fall of 1878

472 Objected to as highly improper, it being leading and clearly suggesting the answer desired.

A. It was.

JOHN F. OTT.

The testimony in behalf of Edison was here closed.

WM. H. MEADOWCROFT,
Notary Public,
New York County.

STATE OF NEW YORK, } ss.: 473
City and County of New York, }

I, WILLIAM H. MEADOWCROFT, a Notary Public within and for the City and County of New York and State of New York, do hereby certify that the foregoing depositions of Thomas A. Edison, Z. F. Wilber, Francis Jehl, John Kruesi, Francis R. Upton and John F. Ott were taken on behalf of Thomas A. Edison, in pursuance of the notices hereunto annexed, before me, at No. 65 Fifth avenue, in the City of New York, on the 15th, 18th and 19th days 474
of October, and the 8th, 9th, 10th, 11th and 12th days of November, 1881; that each of the said witnesses was by me duly sworn before the commencement of his testimony; that the testimony of the said witnesses was, by consent of all parties, written out by Henry W. Seely, he having been by me first duly sworn to record the same faithfully; that L. L. Leggett, Esq., and H. A. Seymour, Esq., representing the opposing party, Brush, and N. S. Keith, the other opposing party, in person, were present dur- 475
ing the taking of said testimony; that the taking of said testimony was commenced at the place and time designated in said notices and was concluded on the 12th day of November, 1881; and that I am not connected by blood or marriage with any of said parties, nor interested, directly or indirectly, in the matter in controversy.

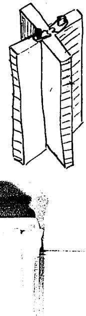
In testimony whereof, I have set my hand and official seal hereto at the City of New York, in the County 476
[SEAL] and State of New York, this 14th day of November, A. D. 1881.

WM. H. MEADOWCROFT,
Notary Public,
New York County.

43

Edison's Exhibit No. 1 W.H.M. Notary Public N.Y. Co.

Make (40) forty resistance Coils.



Body of wood (pine) like sketch 1 foot long and 4 inches across the corners. Fasten the two ends to binding posts that will take No 8 wire and which are fastened to two blocks between which a cut out plug will fit

Mch 4th 1879

" 19 " J.K.

Edison's Exhibit No. 8 - W.H. Meadowcroft
Notary Public
N.Y. Co.

fig 1

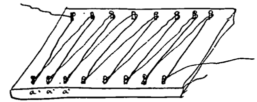


fig 2

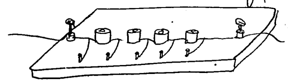
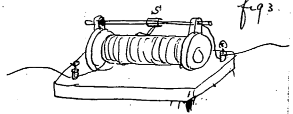


fig 3.



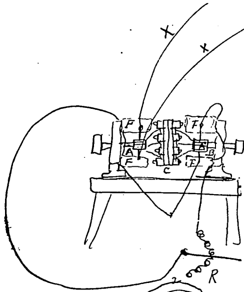


fig 1

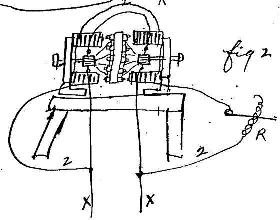


fig 2

"Edison's Exhibit No 9"
W.H. Meadowcroft

Miscellaneous Bound Interferences

This bound volume contains the printed record from four patent interferences and one civil court suit for the period 1880-1885. The spine is stamped "U.S. Patent Office Miscellaneous Interferences of T. A. Edison."

The following cases comprise this volume:

(1) Mather v. Edison v. Scribner (1883). This 52-page pamphlet contains testimony by Edison, John F. Ott, and other associates regarding Edison's work on dynamos between 1881 and 1882.

(2) Edison v. Lane v. Gray v. Rose v. Gilliland (1882). This 12-page pamphlet contains a brief filed on behalf of Edison by George W. Dyer on February 22, 1882 in two related interferences involving dynamos: Edison v. Lane v. Gray v. Rose v. Gilliland; and Edison v. Lane v. Gray v. Edison & Johnson.

(3) Edison v. Nicholson (1880). This 32-page pamphlet contains testimony and other printed records, including correspondence, relating to conflicting claims over duplex telegraph patents. Among the correspondents are Henry C. Nicholson and Edison's attorney, Lemuel W. Serrell.

(4) Sawyer and Man v. Edison (1881). This 198-page pamphlet contains testimony and exhibits on behalf of Edison. Most of the record from this interference (including testimony by Edison, Charles Batchelor, and Francis R. Upton) was later entered as evidence in Edison Electric Light Company v. United States Electric Lighting Company and has been filmed with the other records from that case. Both the interference and the court case concern Edison's work on the incandescent lamp and the validity of his U.S. Patent No. 223,898, the first carbon filament lamp patent.

(5) Edison Electric Light Company v. United States Electric Lighting Company (1885). This pamphlet contains the 8-page bill of complaint filed by the Edison Electric Light Company in 1885. Included also are 13 pages of technical notes and drawings by Edison, which were entered as exhibits in this suit.

Also included in this volume are the records of several telephone interferences from the 1880s. These have been published in Thomas A. Edison Papers Microfilm Edition, Part I, 11: 852.

1

In the United States Patent Office.

MATHER 2

vs.

EDISON } Interference.

vs.

SCRIBNER.

3

DYNAMO OR MAGNETO-ELECTRIC MACHINES.

In pursuance of the annexed notice the parties to the above-named interference attended before me this 3d day of October, 1883, as follows: GEORGE P. BARTON, for Scribner; C. L. BURDETT, for Mather; C. E. SCRIBNER, in person; and RICHARD N. DYER, for Edison.

JOHN F. OTT, a witness produced in behalf of 4
Edison, being duly sworn, deposes as follows, in answer to questions proposed by Richard N. Dyer, counsel for Edison.

1 Q. What is your name, age, residence and occupation?

A. John F. Ott; 33; 18 Gouverneur street, Newark; employed by Mr. Edison making experiments and carrying out tests from sketches furnished by him to me.

6849

5 2 Q. Where were you employed and in what capacity during the summer of the year 1882?

A. At the laboratory, Menlo Park, making tests on regulators and other electrical experiments?

3 Q. Regulators for what purpose?

A. Regulating the pressure of the current of the dynamo and keeping a constant pressure for various loads.

4 Q. When did you commence these trials at Menlo Park and how long did they continue during
6 that year?

A. Somewhere in the latter part of May. I think they wound up in September.

5 Q. What was the date of your going to Menlo Park for this purpose?

A. If I recollect proper, it was the 9th of May, or very close to it.

6 Q. Did the trials of regulators for dynamo electric machines commence immediately after you went there?

7 A. Yes; that is, I arranged immediately for making such tests, but of course it took me two weeks about to get ready, as I had to make test-boards and one thing and another.

7 Q. From whom did you get the explanations from which to make these trials of regulators for dynamo electric machines, and what was the nature of the explanations?

A. Mr. T. A. Edison, at Menlo Park; by sketches giving the outlines of the experiments of the test to
8 be made.

8 Q. Did any of the regulators for dynamo electric machines which you tried for Mr. Edison at that time involve the principle of varying the current for the field magnet circuit by an adjustment at the commutator of the machine?

Question objected to as leading.

A. It did.

9 Q. Please explain the regulators tried by you at 9
that time which involved this principle?

A. It consisted of one or more extra brushes fastened upon an arm, being adjustable either with the other brushes or individually, standing about right angles to the other brushes, or in other words, right angles to the neutral line.

10 Q. What where the connections of the field magnet coils in the regulator you have described?

A. One end was connected to one of the extra brushes and the other to one of the brushes leading 10
to the main line.

11 Q. How many extra brushes were used with the connections that you have just described.

A. With the connections just described there was one extra brush used.

12 Q. How was this extra brush supported?

A. It was supported on a wooden block fastened to an adjustable arm carrying the other two brushes; also arranged to be adjusted with itself independent of the other brushes. 11

13 Q. When the extra brush was arranged to be adjusted independent of the main brushes, what was the construction used for supporting the extra brush?

A. It was a wooden block fastened to the adjustable arm, having a curved arm coming from that holding the other brush at right angles or as near right angles as the circumstances may suit to the other brushes.

14 Q. How was the independent adjustment of the 12
extra brush effected?

A. By loosening up two screws and adjusting it by hand.

15 Q. What was adjusted by hand?

A. The block holding the extra brush.

16 Q. Now please again describe how that block was secured so that it would be adjusted independent of the main brushes?

A. The block having a piece of board somewheres near an inch thick, cut out oblong shape, having a

13 hole in the centre of it admitting the shaft and the commutator of the armature through it, then having two slots where the two screws went through fastening it to the adjustable arm carrying the other brushes and then on this wooden block being fastened by a small arm carrying an extra brush.

17 Q. Now explain how the adjustment of this block carrying the extra brush was made without adjusting the main brushes.

A. It was made by loosening two screws which
14 went into the regular arm carrying the other two brushes, then shifting it by hand and fastening up these two screws again.

18 Q. Was more than one extra brush used in any of these regulators?

A. There was.

19 Q. How many?

A. Two.

20 Q. Please describe the connections of the coils of the field magnet when two extra brushes were
15 used.

A. One end of the field magnet being connected to one brush, the other end to the other.

21 Q. What brushes do you refer to?

A. Extra brushes.

22 Q. How were the two extra brushes supported?

A? On an extra block, as I previously stated.

23 Q. Was this the same block?

A. The same block.

16 24 Q. At what time were these trials made of regulators having one or more extra brushes adjustable by hand, independent of the main brushes?

A. The latter part of May, 1882.

25 Q. Did you, after that time, make any further trials of regulators employing this principle?

A. I did.

26 Q. What were they?

A. Several devices making it automatic.

27 Q. Please explain a little more fully what you mean by making it automatic.

A. What I mean by making it automatic is, that 17
when the person turning off one or more lamps, the pressure being varied on the main line, would be regulated by throwing in an automatic device, shifting the third brush to its proper place, to bring the pressure to a constant.

28 Q. In these automatic regulators, what was the relation between the extra or third brush and the main brushes—I mean the mechanical relation?

A. The mechanical relation was that the third 18
brush being shifted around the commutator, there would be a different pressure, of course throwing less current through the field magnet.

29 Q. Did the automatic mechanism for shifting the third brush have any mechanical effect upon the main commutator brushes?

A. It did not.

30 Q. What were the connections of the field magnet coils in this automatic third brush regulator? 19

A. They were the same as with the hand regulator, the only difference being there was another connection made across the line working the automatic device to shift this third brush.

31 Q. When were these automatic third brush regulators made?

A. In the beginning of June, 1882.

32 Q. What use was made of these automatic third brush regulators at that time?

A. They were used to regulate a set of lamps 20
which were put up in a part of the laboratory commonly called test board with us, and also regulating the lamps in Mr. Edison's house.

33 Q. How were the test board lamps and the lamps at Mr. Edison's house supplied with current. I mean what source of electric energy was employed to supply these lamps?

A. The dynamo current.

34 Q. What did the automatic regulator have to

21 do with that dynamo current. Where was it located?

A. In the dynamo room back of the workshop.

35 Q. You have stated that these lamps were regulated by this automatic regulator. Now I want to know how that automatic regulator was placed—how it regulated these lamps; that is, what the relation was between that automatic regulator and the source of supply for the lamps?

A. The lamps were fed by the current from the
22 main line, while the field being fed from one end of the main line to the third brush.

36 Q. I now call your attention to a patent granted to T. A. Edison for regulators for dynamo electric machines, dated March 6th, 1883, No. 273,487, a copy of which is now handed you. Do you understand the regulator illustrated in the drawing of that patent?

A. I do; it being a third brush regulator involving the same principle as that used by me at Menlo
23 Park, in the latter part of May, 1882.

37 Q. In what essential respect does the automatic mechanism shown in this patent differ from those you employed at Menlo Park at the time you refer to?

A. The difference being the brush being shifted by gearing device in place of a worm wheel.

A printed copy of the patent referred to is put in evidence and marked Edison's Exhibit
24 A.

Counsel for Edison, Mather, and Scribner stipulate to admit printed copies of patents in evidence to have the same force and effect as if duly certified.

Cross-Examination by George P. Barton, Attorney for Scribner.

38 x-Q. Are you the John F. Ott who testified in behalf of Mr. Edison in his interference with

Elisha Gray and others, relating to automatic shunts 25
for cutting out the generator of telephone call boxes?

Objected to as immaterial and incompetent.

A. I never remember being on such a case as that.

39 x-Q. You have frequently testified for Mr. Edison, have you not, during the last two years?

26

Same objection.

A. Yes, sir.

40 x-Q. Do you remember that I once cross-examined you at Menlo Park?

Same objection.

A. I have forgotten all about it, I assure you.

41 x-Q. Do you remember a device made by Edi- 27
son for use upon American District wires, and which was removed from Ward street to Menlo Park?

Same objection.

A. I do.

42 x-Q. You remember giving testimony about that that device, do you not?

Same objection. 28

A. I have forgotten all about it.

43 x-Q. Do you remember the device I refer to?

Same objection.

A. I suppose it is the chemical paper device being the drop of segment.

44 x-Q. Mr. Ott, there was a magneto district signal box. It had a handle which stuck out from the

29 case. It was run by clockwork. Do you remember giving testimony about such a device?

Objected to as immaterial and not proper cross-examination.

A. Yes, I have a faint recollection of giving testimony at that time.

45 x-Q. When was that? What year and what month?

30

Same objection.

A. That I cannot state. I do not know what month it was in.

46 x-Q. Was it in 1882?

Same objection.

A. I cannot tell what year it was.

31 47 x-Q. Do you remember whether that testimony was given before or after the experiments about which you have testified in your direct examination?

A. That I cannot tell. I have forgotten.

48 x-Q. You have testified that you went to Menlo Park on or about May 9th, 1882, and that about two weeks later you commenced the experiments, the intervening time being employed in preparing apparatus. Now state whether those experiments were begun before the 1st of June—are you positive?

32 A. I am positive that they were begun before the 1st of June.

49 x-Q. And you are positive that the first experiments took place during the last two weeks of May, 1882?

A. I am positive.

50 x-Q. In your first experiments, as I understand you, the extra brushes were regulated by hand. Am I correct?

A. Yes, sir; you are.

51 x-Q. When did you first use the automatic device for regulating the brushes? 33

A. When it was finished I cannot exactly state, but I made the drawing to be made in the workshop on the 7th of June.

52 x-Q. Did you make any drawings for the first experiments which you say were made in May?

A. No, I did not.

53 x-Q. Where was the machine that you made your first crude experiments upon?

A. In the dynamo room, back of the workshop at 34
Menlo Park.

54 x-Q. Describe how those first experiments were conducted, and state who was present.

A. They were conducted by running a line from the dynamo room into the laboratory to the lamps at the test board, and also lamps in the office and in Mr. Edison's house, and parties being present was Martin Force, Tom Logan, and that is all I can remember.

55 x-Q. Was Mr. Edison there? 35

A. He came the following day because he had been to New York.

56 x-Q. You have stated that Mr. Edison showed you some sketches about this time. Who made the sketches, and can you produce them?

A. Mr. Edison made the sketches. I think I could produce some of them.

57 x-Q. Did you see him make them?

A. I saw him make some of the sketches.

58 x-Q. Where was he when he made some of 36
them?

A. Menlo Park.

59 x-Q. Please produce them.

A. I cannot here now.

60 x-Q. The first method of regulating the extra brushes was by hand, was it not?

A. Yes, sir.

61 x-Q. Later, and on or about June 7, 1882, you made sketches of an automatic device for regulating an extra brush, did you not?

37 A. Yes, sir; I did.

62 x-Q. Can you produce that sketch which you made June 7th? If so, please do so.

A. I cannot at present.

63 x-Q. Can you do it at all?

A. Yes.

64 x-Q. Where is the sketch which you made June 7th?

A. At the laboratory, Seventeenth street and Avenue B.

38 65 x Q. Why do you not produce it and offer it in evidence?

Counsel for Edison here states that the witness has not the decision in this case of what exhibits should be put in evidence, and that counsel have decided that the particular working drawing referred to shall not be put in evidence in this case.

39 A. Because I was not aware of what I was called over here for, and was not prepared for anything of the kind.

66 x-Q. Will you go and get the sketch and bring it here if your counsel, Mr. Dyer, asks you to do so?

A. Yes, I would, if Mr. Dyer says so.

Counsel for Scribner here requests a recess of an hour in order that witness may produce the drawing made by him June 7th, 1882.

40 Recess here taken for one hour for luncheon.

67 x-Q. Have you found the drawing referred to?

A. Yes, sir.

68 x-Q. Please produce it. Is this it?

A. That is it.

The witness here produces the drawing and says this is it. The same is offered in evidence and marked "Edison's Exhibit B."

69 x-Q. Exhibit B was made by you, as I understand you, June 7th, 1882? 41

A. I have made a mistake, and find it is June 5th instead of June 7th, as I have previously stated.

70 x-Q. State how the automatic device as shown in said exhibit works?

A. The arm shown at the top of the drawing is an arm holding the third brush on a separate shaft in the rear of the dynamo shaft, in the same line with the dynamo shaft, having upon it a worm wheel and a worm meshing into it. Upon the worm 2
shaft are two ratchets cut in opposite directions, on each side of that being two magnets working pawls, —one in one direction, the other in the other—these magnets being brought in play by the pressure relay, as the pressure varies on the main line, the pressure relay not being shown in this drawing. To make the continuous vibration of these magnets to rotate the arm, there is a separate circuit breaker on the end of the dynamo shaft.

71 x-Q. Then, Mr. Ott, as I understand you, you 43
went to Menlo Park May 9th, and Mr. Edison explained to you by sketches the outline of the test which he desired to be made. That for some two weeks you were engaged in perfecting apparatus for making these tests. That the first tests were made the latter part of May, and consisted in mounting one or two brushes on a brush holder fixed to the main brush holder, the positions of the extra brushes being regulated by hand by loosening the thumb screws you referred to; that subsequently you made 44
Exhibit B. Is that correct?

Objected to as an incomplete statement of the witness' testimony.

A. That is correct.

72 x-Q. The extra brushes being mounted as you have described, were they not necessarily moved when the main brushes were moved?

A. Yes, sir.

45 73 x-Q. During this time how frequently did you talk with Mr. Edison; that is, from the 9th of May till the 5th of June, 1882?

A. He came out there almost every day, or every other day. He had other business to attend to outside, and of course could not attend to it all alone at Menlo Park, and requested me to conduct the required experiments and tests and give him curves of such tests, which he approved of when he saw them.

46 74 x-Q. Have you any of the sketches which Mr. Edison used in giving you the outline of the tests to be made?

A. I have not.

75 x-Q. Do you know where they are? Can you produce them?

A. They are in the possession of Mr. Edison.

76 x-Q. Did you see him make them?

A. I did.

77 x-Q. Did he make them for you at this time?

47 A. He did.

78 x-Q. Do you remember those sketches so that you can tell what they were from memory?

A. Yes, sir.

79 x-Q. Did they show the extra brushes attached to the main brushes as you made the first experiments?

A. Yes, sir.

80 x-Q. You are entirely sure on this point, are you?

48 A. Yes, sir.

81 x-Q. How many sketches were there?

A. I am sure I cannot tell.

82 x-Q. Were there more than one?

A. Oh, yes; there were more than one.

83 x-Q. Could you reproduce those sketches from memory?

A. Yes, sir.

84 x-Q. Please do so?

Counsel for Edison objects to this request

on the part of counsel for Scribner on the ground that the reproduction of the sketches would not be the best evidence of what the sketches themselves show, and the witness is instructed that he need not comply with this request. 49

Counsel for Scribner objects to the instructions given to the witness by counsel for Edison and requests the magistrate to instruct the witness that it is his duty to comply with the request of counsel for Scribner and reproduce the said sketches. 50

NOTARY: I do not understand that I have power under the rules of the Patent Office to compel the witness to act contrary to the advice of his counsel.

Counsel for Scribner repeats his request to the magistrate and asks whether he will instruct the witness as requested.

NOTARY: As I before stated I do not think I have the power and therefore cannot put myself upon record as either declining or acceding to the wishes of counsel for Scribner. 51

A. Having been instructed by Mr. Dyer not to do so I decline to do as requested.

Counsel for Scribner here gives notice that that he shall insist upon the witness complying with his request and that he will move to strike out all of the testimony of the witness unless his request is complied with. 52

85 x-Q. When did you last see the sketches made by Mr. Edison?

A. In July, 1882.

86 x-Q. Where were they?

A. Menlo Park.

87 x-Q. In whose possession?

A. In mine.

53 88 x-Q. About how many were there?

A. I should say there were about half a dozen.

89 x-Q. Describe them?

A. They were sketches showing the position of one extra brush, and some showing the position of two extra brushes; also showing the direction of the current with the brushes in such a position, and the direction of the current flowing, when the brushes were shifted, in another direction.

90 x-Q. How was the single extra brush attached
54 to the main brushes as shown in the sketches?

A. Either from pillow block or brush-holder arm.

91 x-Q. Was the wooden block shown with the single extra brush in the sketch?

A. The sketch showed a method that a block or any insulating material might be used to fasten this third arm upon and be made adjustable with or without the other brushes.

92 x-Q. In the sketch which showed the single extra brush, was there a slot for the screw by which
55 the extra brush was adjusted?

A. I received an explanation with the sketch that it might be made in that way, and Mr. Edison left it entirely for me to carry the balance of it out.

93 x-Q. Then the slot was not shown in the sketch which showed the single extra brush, as I understand you?

A. No, I did not say that. I only say that I do not remember whether it was or not. But I do know the explanation was given.

56 94 x-Q. Who gave you the explanation?

A. Mr. Edison.

95 x-Q. Were slots shown in the sketches which represented two extra brushes?

A. They were.

96 x-Q. Have you now fully described all that you consider novel or peculiar in the sketches made for you by Mr. Edison in May, 1882?

A. To the best of my recollection I have.

97 x-Q. The sketches then showed two modifications of the invention. One form consisted of a

single brush attached to an adjustable brush-holder, 57
and the other showed two extra brushes attached to an adjustable brush-holder, and the extra brushes were to be regulated by loosening screws which were in a slot and then adjusting the brushes by hand?

A. Yes, sir.

98 x-Q. What further instructions, if any, did Mr. Edison give you besides the sketches?

A. He gave me an explanation how to go to
work and make them; also the results that might 58
be noticed, and instructed me to guard against these results and give him a copy of the notes.

99 x-Q. What do you mean by saying "he instructed me to guard against certain results?"

A. What I mean by guarding against results is that in all experiments they are liable for results unknown to turn up; and, in case such should turn up, to make it known, as it might lead to an invention.

100 x-Q. Did you notice during these experiments 59
any such new results; and, if so, what?

A. I noticed several results but do not think it my place to explain them here.

101 x-Q. Did you report the new results which you say you observed, to Mr. Edison.

A. I did.

102 x-Q. In writing, or verbally?

A. Verbally.

103 x-Q. What were they?

A. The peculiarities in the curves given of the 60
different electro motive force on the line, or in other words, peculiar positions that the brushes had taken.

104 x-Q. Any other?

A. That is all.

105 x-Q. Did Mr. Edison, at this time, consider the new result which you have described above as new to himself?

A. Mr. Edison is never in the habit of expressing his opinion on that subject to anybody.

61 106 x-Q. He did not then express an opinion at this time?

A. He did not; not to me.

107 x-Q. Your object then in conducting these experiments, as far as you know, was to find out what would be the effect of using one or more extra brushes upon a dynamo machine as you have described?

A. My object in the experiments was to determine the practicability of these things rather than
62 the experiment of determining what the result would be.

108 x-Q. Did these experiments convince you that it was practicable and useful to use one or more extra brushes as you have described?

A. Yes, sir; they did.

109 x-Q. When were the first sketches made of the automatic device for regulating the single extra brush?

A. It was either in the latter part of May, or in
63 the first part of June.

110 x-Q. Who made them?

A. Mr. Edison.

111 x-Q. Did you see him make them?

A. Yes, sir.

112 x-Q. Can you produce them?

A. I cannot.

113 x Q. Where are they?

A. I suppose in the possession of Mr. Edison.

114 x-Q. When did you see them last?

64 A. I think it was in July or August, 1882.

115 x-Q. They were made then immediately after the first tests which were made after you went to Menlo Park?

A. Yes, sir.

116 x-Q. And grew out of those experiments did they not?

A. Yes, sir.

117 x-Q. Are you acquainted with Charles E. Scribner one of the parties to this interference?

A. I do not know him.

118 x-Q. Did you in May, 1882, know of any other experiments made by other parties than Mr. Edison 65
in which one or more extra brushes were used for the purpose described?

A. I did not.

119 x-Q. Then you consider the extra brush or brushes as shown in Mr. Edison's sketches and as experimented with by you new at that time, did you not?

A. To my knowledge, yes. But I have found a sketch since laying around that dates back of that 66
which I turned over to the care of the company at 65 Fifth avenue.

120 x-Q. Can you produce it?

A. Yes, sir.

121 x-Q. When did you last see it—the sketch which you say you turned over?

A. I should judge within a month.

122 x-Q. Have you not seen it within a week?

A. No, sir, I have not.

123 x-Q. What was the date on the sketch? 67

A. That I do not recollect.

124 x-Q. Where did you find it?

A. Among some drawings that were stored away in the laboratory.

125 x-Q. When did you find it first?

A. I think it must have been about May 1st, 1883.

126 x-Q. Did you find it at Menlo Park?

A. No, sir.

127 x-Q. Where did you find it?

A. At the laboratory of T. A. Edison at Seven- 68
teenth street and Avenue B.

128 x-Q. How came you to find it? Did you just accidentally come upon it? What prompted it?

A. Because it was belonging to that class of experiments.

129 x-Q. You were looking up drawings then in this matter?

A. No, sir, I was not.

130 x-Q. You say it antedated the sketch made for you in May, 1882. Have you any recollection

69 as to how much it antedated May, 1882. Any vague idea?

A. No, I have not. I have forgotten all about it.

131 x-Q. Then, until you found that sketch you believed that the sketch which Mr. Edison made for you in May, 1882, showed a new device. That is, a device new at that time?

A. To the best of my knowledge, I was ready to believe that way.

132 x-Q. That is, your conversation with Mr. Ed-
70 ison led you to believe to that effect?

A. Yes, as to the sketches and not as to the conversation.

Re-direct examination by Mr. Dyer:

133 Re-d.Q. Have you the block for supporting the extra brush or brushes which was used by you during the latter part of May, 1882.

A. Yes, sir.

71 134 Re-d.Q. Is this the block (block shown witness)?

A. Yes. sir.

The block referred to is offered in evidence and marked Edison's Exhibit C.

135 Re-d. Q. When this block was secured in position, was it not possible by loosening the screws connecting this block with the arm carrying the
72 main brushes, to adjust the main brushes without adjusting the extra brush or extra brushes carried by the block?

A. It was possible.

Re-cross-examination by Mr. Barton:

136 Re-x-Q. Was it ever used in that way?

A. Yes, sir; it was.

137 Re-x-Q. By whom?

A. By Mr. Edison and myself.

138 Re-x-Q. Together or independently of each 73
other?

A. Both ways.

139 Re-x-Q. If the screws which held the wooden block were already resting against the end of the slot, it would be impossible to adjust the main brushes in that direction, without moving the extra brushes, would it not?

A. Yes, sir.

140 Re-x-Q. How long was Exhibit C in use?

A. About two or three days. 74

141 Re-x-Q. How long was the automatic device made from drawing Exhibit B kept in use?

A. Several weeks—about three.

J. F. Ott.

Adjourned to Thursday, October 4th, at 10 A. M.

75

76

77 Met, pursuant to adjournment, this 4th day of October, 1883.

Same parties present.

MARTIN N. FORCE, a witness produced on behalf of T. A. Edison, being duly sworn, deposes and says, in answer to questions proposed by Richard N. Dyer, counsel for Edison, as follows:

1 Q. What is your name, age, residence and occu-
78 pation?

A. Martin N. Force; age, thirty-four; residence, Menlo Park; occupation, assistant to Mr. Edison.

2 Q. Where were you during the summer of the year 1882?

A. On the 28th of April I returned from Europe, and in about a week or ten days from that time I went into the laboratory to work at Menlo Park.

3 Q. Do you recollect of trials of regulators for dynamo electric machines after you resumed work
79 in the laboratory?

A. Yes, sir; I do.

4 Q. By whom were those trials conducted?

A. By Mr. Ott.

5 Q. I now call your attention to the device marked Exhibit C. Do you recognize the same?

A. Yes, sir; I recognize the piece Exhibit C.

6 Q. When did you first see it, and what was it used for?

A. I remember seeing it in the latter part of May,
80 1882. It was used for the regulation of the field circuit of a dynamo machine.

7 Q. Please explain the circumstances under which you saw it used?

A. I saw Exhibit C fastened to the arm holding the main brushes by two thumb screws passed through the slots on the exhibit.

8 Q. What was carried by this piece, Exhibit C, at that time?

A. Two brushes.

9 Q. Were these the only brushes that the ma- 81
chine was provided with?

A. No, sir. The machine had two other brushes.

10 Q. What were these two other brushes?

A. They were the line brushes.

11 Q. What was the construction of the dynamo machine to which this regulator, Exhibit C, was applied with reference to the number of commutator cylinders?

A. It is the regular Edison dynamo machine,
known as the "Z" machine. I think the number 82
of commutator bars was 74.

12 Q. How many commutator cylinders did the machine have?

A. It was one cylinder.

13 Q. Do you recollect the use of any other regulator on dynamo electric machines at Menlo Park, subsequent to the use of Exhibit C, in which were employed more commutator brushes than the ordinary or line commutator brushes of the machine?

A. I recollect the automatic third brush regulator 83
used on the machine running the lights at Mr. Edison's house and office.

14 Q. When was this automatic third brush regulator so used?

A. From the early part of June, 1882, up to about October, 1882.

15 Q. What was the occasion of the discontinuing the use of this regulator?

A. The moving into New York of the office and
Mr. Edison's family. 84

16 Q. I now call your attention to the working drawing, Exhibit B; do you recognize the mechanism shown by this drawing?

A. I recognize Exhibit B as being the mechanism of the automatic third brush regulator I which have before referred to.

CROSS-EXAMINATION BY GEORGE P. BARTON, ESQ., ATTORNEY FOR SCRIBNER:

17 x-Q. How long were you in Europe?

A. Somewhere about ten months.

85 18 x-Q. Did you assist Mr. Ott in his experiment in May and June, 1882?

A. No, sir; I did not.

19 x-Q. Did you see Mr. Ott when he made the drawing marked Edison Exhibit B.

A. Yes, sir; I saw him working on that drawing.

20 x-Q. Who was present at the time, besides yourself and Mr. Ott?

A. A young man by the name of Frank Wardlaw
86 was most of the time present.

21 x-Q. Was Mr. Edison present at any time while Exhibit B was being made?

A. I think he was.

22 x-Q. Do you remember that he was, or is it simply an impression?

A. I am not positive that he was there at that particular time he was making the drawing.

23 x-Q. Then, as far as you know, the mechanism shown by Exhibit B was the invention of Mr. Ott,
87 was it not?

A. Not the invention of Mr. Ott. I stated that the drawing was made by Mr. Ott. Mr. Edison is generally the inventor.

24 x-Q. You think then that Mr. Edison was the inventor of the system shown in Exhibit B, simply because it was Mr. Ott's business to work for Mr. Edison and put Mr. Edison's inventions into mechanical shape. That is one of the reasons, is it, why you think so?

88 A. Yes.

25 x-Q. But you did not see Mr. Edison directing Mr. Ott at any time while Exhibit B was being made?

A. I cannot recall to mind a particular time while Mr. Ott was making that particular drawing, when he gave any direction to the work of making the drawing.

26 x-Q. Was he present at any particular time, that you can recall, during the time Mr. Ott was

testing the machine that was made from the Exhibit B. 89

A. I do not recall any particular time. But he was usually around most every day.

27 x-Q. Did you not in June, 1882, understand that the automatic mechanism for regulating the third brush as shown in Exhibit B, to be the invention of Mr. Ott?

A. No, sir: I never understood it being the invention of Mr. Ott.

28 x-Q. Whose invention did you understand it to be? 90

A. I understood it to be the invention of Mr. Edison.

29 x-Q. Did Mr. Edison take any part in the experiments made with Exhibit C in the latter part of May, 1882, if so tell what Mr. Edison said and did?

A. I do not remember of his taking any part as I myself was not connected with the experiment personally, although he may have. 91

30 x-Q. Did you see the dynamo in use for generating electricity while Exhibit C was attached thereto in May, 1882?

A. Yes, sir; I saw it running.

31 x-Q. Did you trace the circuits of the machine?

A. No, sir; I did not trace the circuits.

32 x-Q. There were two extra brushes mounted on the wooden block marked Exhibit C at that time?

A. Yes, sir; there was at the time I saw it. 92

33 x-Q. Were both of those brushes in use at the same time. Could you tell from the appearance of the machine?

A. They were in use at the same time, both making contact at the commutator.

34 x-Q. Do you know that both brushes were in circuit simultaneously, and if so, how?

A. Yes, sir; I knew they were both in circuit. I saw Mr. Ott adjust the brushes and from a lamp that was in, I saw the light raised and lowered.

93 35 x-Q. Did you see Mr. Ott when he first attached Exhibit C to the machine, and when he first run it?

A. I cannot say I saw him make the attachment.

36 x-Q. Did you see the machine in operation the first day of the experiments with Exhibit C?

A. I cannot say whether it was the first, second or third day, I cannot recall to memory the day.

37 x-Q. What is your best recollection as to the
94 day?

A. My best recollection is that Exhibit C was used for regulator in the latter part of May, 1882, for egulating field circuit of a dynamo machine.

38 x-Q. How many days was it used?

A. I cannot say how many days. I remember it being used in the latter part of May, '82. Directly after this followed Exhibit B in the early part of June of 1882.

39 x-Q. You saw Exhibit C in use more than
95 once, did you not?

A. Yes.

40 x-Q. More than twice?

A. I don't attempt to say how many times I saw it. I am willing to swear positively that I saw it in running order more than twice.

41 x-Q. Did you see it in use on different days more than three times?

A. I do not recall to mind whether it was different days or not.

96 42 x-Q. Then you are not positive that you saw the machine in use with Exhibit C attached, on more than one day, are you?

A. I don't remember whether it was more than one day or not. I can't remember the number of days and number of times I saw it running. I saw it running in the latter part of May.

43 x-Q. How do you fix the date as the latter part of May rather than the 3d of June?

A. From experiments that I was myself connected with at that time for Mr. Edison.

44 x-Q. As I understand your testimony you 97
say you saw the machine with Exhibit C attached in use immediately before Exhibit B was made. You say that it must have been the latter part of May because you were making some other experiments about that time for Mr. Edison. How do those other experiments lead you to think you saw Exhibit C attached to a running machine the latter part of May.

A. After my return from Europe, which was on
the 28th of April, 1882, I was home then for some 98
ten or twelve days before returning to work. Mr. Ott was then working on regulators when I returned, which was along about the middle of May. Mr. Ott asked Mr. Edison that I might assist him in his experiments and Mr. Edison said, "no, I have some other things I want him to try." That is why I fix the date by those experiments.

45 x-Q. Your attention was not then particularly called to this invention in May, 1882, was it?

A. Not particularly. 99

46 x-Q. And you paid no particular attention to the time when Mr. Ott got ready to make the first experiments with the extra brushes. Am I correct?

A. Not to any particular day, but it followed directly after his asking for my assistance.

47 x-Q. Then you have no data further than your general recollection by which you can fix the date of the first experiments with the extra brushes?

A. I will add that after Mr. Edison refusing to 100
let me assist Mr. Ott, he (Ott) took Wardlaw, that I have already mentioned, and I remember hearing Ott tell Wardlaw to cut out a piece of board for an experiment.

48 x-Q. Is Exhibit C the board?

A. It was like that.

49 x-Q. Did you yourself understand the nature of the experiment for which the board was to be used at that time?

A. I understood it to be for a third brush regulator.

101 50 x-Q. From whom did you get your information? You got it from Ott or Wardlaw, did you not?

A. I got it from Mr. Edison and Ott when the question was asked if I could assist him.

51 x-Q. Did Mr. Edison at that time say anything as to the results he expected from the experiments?

A. I don't remember of hearing him say anything at that time as to the results.

52 x-Q. State, as nearly as you can, the substance of the language used by Mr. Edison at the time Mr.
102 Ott asked him to let you assist in the experiments?

A. When Mr. Ott asked Mr. Edison the question Mr. Edison said, as near as I can remember, "Can't you get somebody else, I have some other experiments I wish him to try?"

53 x-Q. Then, at that time, Mr. Edison did not say anything about the extra brushes or anything descriptive of the invention which Mr. Ott was to test?

A. Not at that time as near as I can remember.

103 54 x-Q. Did Mr. Ott say anything descriptive of the invention at that time?

A. I do not remember of his saying anything.

55 x-Q. When and how then did you first learn the nature of the invention which was to be tested with Exhibit C?

A. On or about that time by Mr. Ott.

56 x-Q. At the conversation between Mr. Edison and Mr. Ott did Mr. Ott say anything about the third or extra brushes?

104 A. To what conversation do you refer?

57 x-Q. The one in which Ott asked Edison to let you help conduct the experiments?

A. Not to my recollection.

58 x-Q. (x-Q. 49 and 50 read to witness). You were in error then, were you not, when you said in answer to x-Q. 50, "I got it from Mr. Edison and Ott when the question was asked if I could assist him."

A. When Mr. Edison asked Mr. Ott I got the idea of a regulator, as I have already stated. At that conversation there was nothing said to my recollec-

tion of a third brush by either Mr. Edison or Mr. Ott. 105

Re-examination:

59 Re-d. Q. What is the time that you refer to in your answer to x-Q. 49?

A. At the time when Ott ordered Wardlaw to make the board.

60 Re-d. Q. What information do you refer to in your answer to x-Q. 50?

A. I referred to a more detailed explanation. 106

61 Re-d. Q. What was the information which you obtained from Edison and Ott, as stated in answer to x-Q. 50?

A. The information that I obtained from that was for a regulator to be used for regulating the field of a dynamo machine.

62 Re-d. Q. Did the information you obtained from Ott and Edison, referred to in your answer to x-Q. 50, relate to any particular form of regulator, or was it general? 107

Objected to by counsel for Scribner as leading.

A. At that time there was no particular form specified that I can remember, except that it was to regulate the field of a dynamo machine.

63 Re-d. Q. Is this the information which you referred to in your answer to x-Q. 50?

A. Yes. 108

64 Re-d. Q. How much of the time were you present when Mr. Ott was engaged making the working drawing Exhibit B.

A. Only occasionally when I happened in the room where he was working. I was engaged in another part of the building.

Re-cross-examination by Counsel for Scribner:

65 Re-x-Q. Who first spoke of regulating the field

109 of a dynamo machine—Edison or Ott—at the conversation referred to in answer to 62 Re-d.Q.?

A. I don't remember.

66 Re-x-Q. Are you sure that regulating the field of a dynamo machine was referred to at that time by anyone?

A. Yes, sir; I am quite sure.

67 Re-x-Q. But by whom you do not know.

A. I do not call to mind who the reference was made by.

110 Q. But it was during the conversation between Ott and Edison?

A. To the best of my memory the reference was made somewhere about that time.

68 Re-x-Q. But you are not certain as to the particular conversation. The reference may have been made first during some later conversation between Mr. Edison and Ott and not the conversation in which Ott asked for your assistance?

A. I can't remember exactly what time the refer-
111 ence was made, but it was during the early experiments.

MARTIN N. FORCE.

A recess is here taken for thirty minutes.

112

WILLIAM H. MEADOWCROFT, a witness produced 113
on behalf of T. A. Edison, being duly sworn, deposes and says, in answer to questions proposed by Richard N. Dyer, Esq., Counsel for Edison, as follows:

1 Q. What is your name, age, residence and occupation?

A. William H. Meadowcroft; age, 30; residence, 320 West Twenty-second street, New York City; occupation, Private Secretary, and also Notary 114
Public for the County of New York.

2 Q. Was the oath attached to the application of Thomas A. Edison for improvement in dynamo or magneto-electric machines filed August 7th, 1882, and involved in this interference sworn to before you, and if so, at what date? You may refresh your memory by reference to a certified copy of said oath, which I now hand you.

Question objected to by counsel for Scribner 115
as leading.

A. The oath of which this is a certified copy was sworn to before me on the 1st day of March, 1882.

The certified copy referred to is put in evidence and marked Edison's Exhibit D.

The Exhibit D objected to as incompetent, not being the best evidence.

116

3 Q. What has been your practice with regard to the execution of oaths of this character?

Objected to as irrelevant, his general practice not forming part of the issue in this case.

A. My general practice has been to date affidavits on the day they were sworn to, and I have never once departed from this rule. These applications of Mr. Edison are usually brought to me all complete, with the exception of having been sworn to.

117 I take Mr. Edison's oath to them, and sit right down and sign and seal them at once. This has been my uniform practice.

4 Q. Did the application of Mr. Edison involved in this interference form in any manner an exception to the uniform practice which you have stated?

A. No.

118 CROSS-EXAMINATION DE BENE ESSE BY GEORGE P. BARTON, ATTORNEY FOR SCRIBNER:

5 x-Q. When you took Mr. Edison's acknowledgment to the affidavit referred to, did you pay any attention to, or know in any way what, the invention was which is referred to in the affidavit: "The within described invention?"

A. I certainly did at the time. I take a great interest in all Mr. Edison's inventions, and have always taken a hasty glance through specifications
119 sworn to by me. But there are so many specifications that I have sworn Mr. Edison to, I cannot, without having the original before me, thoroughly identify it.

6 x-Q. The oath is the general form which you used in all of Mr. Edison's cases, is it not, and may be attached to the specification of any invention without any change, may it not?

A. This is the form of oath which was in use at the time that I swore Mr. Edison on the oath in
120 question. That was while Major Wilbur had charge of the soliciting of patents. Since Mr. Dyer has had this business on his hands, I believe the form of oath has been changed. I do not know whether the form of oath on Exhibit D would meet the requirements of the Patent Office if annexed to the specification of any invention by Mr. Edison. I do not prepare these oaths myself; they are prepared by the attorney who draws the specification, and whom, I suppose, is familiar with the practice that is required by the Patent Office.

7 x-Q. You used a printed form, did you not? 121
A. Yes. It was annexed by Major Wilbur to the end of the specification.

RE-DIRECT EXAMINATION:

8 Re-d-Q. Please explain the reason for the interest in the Edison inventions, and for the examination of his applications, which are sworn to before you?

Objected to as irrelevant. 122

A. In my position as private secretary to the President of the Edison Electric Light Company, I am expected to keep myself informed as to the number and subjects of Mr. Edison's inventions, and have for that reason always taken an interest in looking at the specifications which pass through my hands.

Counsel for Scribner gives notice that at the 123
hearing he shall move to have the foregoing deposition excluded, as not being the best evidence, therefore incompetent.

WM. H. MEADOWCROFT.

The taking of testimony is postponed subject to further notice.

WM. H. MEADOWCROFT,
Notary Public, 124
New York County.

125 In accordance with the accompanying notices hereto annexed, the taking of testimony in this case was resumed this fifth day of November, at 11 A. M.

Present—Geo. P. Barton, Esq., for Scribner, and C. E. Scribner in person, and Richard N. Dyer, Esq., for Edison.

Samuel D. Mott, a witness produced in behalf of
126 Edison, being duly sworn, deposes and says in answer to questions proposed by Richard N. Dyer, Esq., counsel for Edison, as follows:

1 Q. What is your name, age, residence and occupation?

A. S. D. Mott, age 30; residence, New York City; occupation, electrician.

2 Q. Where were you employed during the years 1881–82?

127 A. I was employed by the Edison Electric Light Company, stationed in this building, in 1881, until about the first of June, 1882.

3 Q. In what capacity?

A. Draughtsman. I made Patent-Office drawings.

4 Q. Do you recognize the sketches I now hand you?

A. Yes. I recognize them.

5 Q. What are they?

128 A. I recollect the drawings very well, my signature and date, and Mr. Edison's writing designating it caveat.

Sketches referred to are put in evidence, and are marked respectively Edison Exhibit D and E.

7 Q. By whom was the sketch Exhibit D made?

A. It was made by Mr. Edison.

8 Q. Please explain what it shows? 129

A. Shows a dynamo machine, two brushes, which are the main brushes, and two brushes which are on a handle automatically operated and adjustable independent of the main brushes. The circuit from the adjustable brushes energizes the field.

9 Q. In whose handwriting is the word "caveat" on this sketch?

A. In Mr. Edison's.

10 Q. In whose handwriting are the date and the signature, "S. D. Mott?" 130

A. My own.

11 Q. When did you witness this sketch?

A. When I received it from Mr. Edison.

12 Q. What does the date on the sketch indicate?

A. It indicates the day I signed it as a witness.

13 Q. What does the figure at the bottom of sketch Exhibit E show?

A. It shows two main brushes, from which the main circuit is taken, and one adjustable brush, worked automatically, the circuit from the adjust- 131
able brush energizing the field.

14 Q. Do you recognize the handwriting of the word "caveat" on this sketch?

A. I do.

15 Q. Whose is it.

A. Mr. Edison's handwriting.

16 Q. Is that your signature upon the sketch?

A. Yes.

17 Q. In whose handwriting is the date January
3, 1881? 132

A. My own.

18 Q. What does that date indicate?

A. The day I signed it as a witness.

19 Q. Under what circumstances did you witness the sketches Exhibits D and E?

A. Because I usually witnessed sketches given me by Mr. Edison.

20 Q. Do you recognize the drawing on tracing cloth which I now hand you?

A. I do.

133 21 Q. By whom was it made?
A. By myself.

Drawing referred to is hereby put in evidence and marked Edison's Exhibit F.

22 Q. When was that drawing made?

A. It was made within a few days after I received the sketches D and E; certainly within a week.

23 Q. Do any of the figures of this drawing F
134 correspond with those of the sketches D and E?

A. Yes, sir; figures 1, 3 and 4.

24 Q. For what purpose was this drawing F made?

A. It was to be filed in the Patent Office as a caveat.

Cross-examination by George P. Barton, Esq., Attorney for Scribner:

135 25 x Q. Do you know why this Exhibit F was not filed as a caveat in the Patent Office?

A. Not of my own knowledge.

26 x-Q. Do you, of your own knowledge, know that any use was made of the drawing?

A. I was not supposed to know anything about it after it leaves my hands.

27 x-Q. You do not in fact, then, know of any use it was put to?

A. No, sir; I do not.

136 28 x-Q. Did you have any conversation with Mr. Edison about these sketches, Exhibits D and E?

A. None that I recollect.

29 x-Q. Did Mr. Edison give you any instructions at that time with reference to the sketches?

A. No; not to my recollection. The sketches spoke for themselve.

30 x-Q. Did Mr. Edison describe to you the operation of the apparatus which the sketches are designed to represent?

A. Probably not. I didn't need any description. It was simple.

31 x-Q. Then at the time these sketches were 137
given you, you understood from the sketches what they were designed to represent and the operation of the apparatus, as therein shown.

A. I knew then what they were designed to represent, but it was not necessary for me to understand the operation to make the drawing.

32 x-Q. But you did understand their operation at that time?

A. Yes, I think I did.

33 x-Q. Do you know as much about them now 138
as you did then?

A. Yes.

34 x-Q. You know more than you did then, do you?

A. No; I don't know as I do. My knowledge of the *modus operandi* is the same now as then.

35 x-Q. And as I understand you, your knowledge now as well as then, is the result of simply inspecting the sketches.

A. Knowledge of them, yes. 139

36 x-Q. Describe the figure 3 of Exhibit F?

A. It is a dymano machine, two main brushes from which the main circuit is taken, and a single brush worked automatically through an adjustable handle, which single brush takes off more or less current as lamps are added to or taken from the main circuit, in order that they may be constant in their illuminating effects by regulating the field or generating capacity of the machine. That is as I
understand it. In other words, an automatic regu- 140
lator.

37 x-Q. In order to increase the strength of the current on the main or lamp circuit must the third brush move up or down as shown in figure 3?

A. It must move up.

38 x-Q. And to decrease the strength of the current in the main circuit it must move down?

A. Yes. It approaches or recedes from the point of maximum effect.

141 39 x-Q. This is true, also, of the third brush shown in the figure at the bottom of sketch E?

A. Yes.

40 x-Q. And this is the way you understood the operation of the apparatus when Mr. Edson first showed you the sketches, is it not?

A. It is.

RE-EXAMINATION BY R. N. DYER:

142 41 Re-d. Q. Were you at work in this building, No. 65 Fifth avenue, during the entire year of 1881?

A. All but January. I came from Menlo Park in February: the rest of the year I was located in this building.

42 Re-d. Q. Was the nature of your employment changed when you moved to New York?

A. No.

43 Re-d. Q. Where were these sketches D and E and the drawing F made?

143 A. At Menlo Park.

44 Re-d. Q. What was Mr. Edison's habit in regard to giving you instructions when he handed you sketches to make drawings from?

> Objected to on the ground that Edison's custom is not relevant to the issues in its controversy.

A. "Mott, make this for patent," or "caveat," as

144 the case might be.

S. D. MOTT.

RICHARD N. DYER, a witness produced in behalf 145
of Thomas A. Edison, being duly sworn, deposes and says as follows:

I am the patent solicitor for the Edison Electric Light Company and have been since the first of August, 1882. I have been the patent solicitor for Mr. Edison personally since the first of February, 1882. Before that time, from the 12th of May, 1881, I was employed in the office of Major Z. F. Wilbur, who was the patent solicitor for the Edison Elec- 146
tric Light Company.

About the 7th of February, 1882, I received by mail from Mr. Edison, he being then temporarily at Menlo Park, instructions to prepare the application for patent which is in this interference. Those instructions consisted of a sketch made by Mr. Edison and a description in his handwriting, addressed to me, signed with Mr. Edison's initials and dated February 6th, 1882.

(The sketch and description referred to are put in 147
evidence and marked Edison's Exhibit G.)

The application was prepared by me immediately after receiving these instructions. It was signed by Mr. Edison February 28th, 1882, and sworn to by him on the first of March, 1882.

The application was then turned over by me to Major Wilbur for filing, since it was to be assigned to the Light Company.

He did not file the case, but kept it with a large number of other cases for which he collected the 148
first Government fees from the Light Company, and after the first of August, '82, when I took charge of the Light Company's soliciting business, I obtained this case with others from Major Wilbur and filed it.

Before preparing the application in the interference, recollecting that I had seen something similar among Mr. Edison's caveat drawings in Major Wilbur's possession, I looked over those drawings and found the drawing Exhibit F. The principles em-

149 bodied in figures 3 and 4 of Exhibit F, I included in the application: the pencil marks on figures 3 and 4 were made by me at that time, February, 1882, to guide the draftsman in making the drawing for the application. This drawing, Exhibit F, was among the loose drawings in Major Wilbur's office, when I entered his employ on the 12th of May, 1881. At that time I made a careful examination of the drawings in his office and Exhibit F was among them.

150 During the summer of 1882, from about the first of May until the last of September, my office was located at Menlo Park, N. J. The application upon which Patent 273,487, Edison's Exhibit A, was granted, was prepared by me at Menlo Park, on the 7th of June, 1882. At that time electric lamps in Mr. Edison's house and in the office were being supplied with current from a dynamo located in the machine shop. At about the time the application upon which Patent Exhibit A was granted was
151 prepared, this machine was provided with an automatic regulator substantially such as shown and described in the patent. It consisted of one extra brush which was mounted upon an arm adjustable independently of the yoke which carried the two main brushes. One end of the field coils of the machine was connected to this extra brush, the other end to one of the main brushes. The extra brush was shifted to regulate the machine by an electro magnetic mechanism, substantially like that
152 shown in the Patent Exhibit A.

CROSS-EXAMINATION BY GEO. P. BARTON:

1 x-Q. How do you know that Major Wilbur collected the first fee from the Edison Electric Light Co., for the application in this interference?

A. This case was among a large number of cases which I received from Major Wilbur immediately after taking charge of the business and upon which I was then informed by the officers of the Light

Company Major Wilbur had collected the first 153
fees.

2 x-Q. Then you have no knowledge on the subject, except what you have heard from hearsay; am I correct?

A. I can go further, and state that I examined the accounts of Major Wilbur with the Light Company and saw his vouchers for the first fees on the cases referred to, of which the application in this interference was one. I also at that time examined reports of Major Wilbur to the Light 154
Company, in which he stated that these cases had been filed.

3 x-Q. Please produce the voucher given by Major Wilbur to the Company for the first fees in this case?

Adjourned to November 6th, at 10 A. M.

155

Met pursuant to adjournment this 6th day of November, 1883.

Present—GEORGE P. BARTON, ESQ., for Scribner; C. F. SCRIBNER in person, and RICHARD N. DYER, ESQ., for Edison.

CROSS-EXAMINATION OF R. N. DYER, CONTINUED:

A. I now produce a copy of Major Wilbur's ac- 156
count for the month of March, 1882. (The said copy is here put in evidence and marked Edison's Exhibit H, and the original of said account is submitted to counsel for Scribner for examination and comparison with copy and will be produced at the hearing if called for). The application in this interference bears Mr. Edison's personal No. 404, and by such number it is referred to in Major Wilbur's account. The first item of March 28th in that account is for first fees paid upon a number of cases,

157 of which this case 404 is one. The account shows that during the month of March, Major Wilbur received $650, part of which was to be applied to the payment of Government fees. One of those fees was the first fee in this case, 404, which is the application in this interference.

4 x-Q. Then this statement of Major Wilber as to the payment of the first fee in this case is false, is it not?

A. It is.

158

RICH'D N. DYER.

159

160

THOMAS A. EDISON, a witness produced on his own behalf, being duly sworn, deposes and says, in answer to questions proposed by RICHARD N. DYER, as follows: 161

1 Q. What is your name, age, residence and occupation?

A. Thomas A. Edison; 37; residence, New York; occupation, inventor.

2 Q. When first, if ever, did you conceive the invention of a regulator for dynamo-electric machines 162
employing the principle of an adjustment at the commutator of the machine for affecting the field magnet?

A. About December, 1880.

3 Q. What was the nature of the regulator you then conceived?

A. The employment of an extra brush or brushes placed on the commutator to obtain a lower electro motive force to energise the field of force magnets.

163

4 Q. Did the conception include any means for varying the energy of the field of force magnets?

Objected to as leading.

Q. Yes, sir; the brushes were to be moved from high to low potential or *vice versa*, to regulate the strength of the field of force magnets. They were to be adjusted independently of the main line brushes.

164

5 Q. I now call your attention to sketches Exhibits D and E. Do you recognize these sketches?

A. Yes, sir.

6 Q. What do they represent?

A. Exhibit D represents a pair of extra brushes on the commutator, which brushes are connected to the field of force magnets and are movable in either direction to obtain no current or a current of variable strength. Exhibit E shows in the lower part an extra brush connected to the field of force mag-

165 nets, one of the main line brushes being connected to the other end of the field of force magnet, the movement of the extra brush serving to increase or diminish the strength of the current in the field of force magnet.

7 Q. How are the extra brushes supported in these sketches?

A. They are supported on an arm independent of the main line brushes, which arm is capable of moving in either direction round the shaft of the arma-
166 ture.

8 Q. By whom were those sketches made?

A. They were made by myself.

9 Q. When?

A. Within two or three days before January 3d, 1881.

10 Q. In whose handwriting is the word "caveat" on each of these sketches?

A. My handwriting.

11 Q. For what purpose were these sketches
167 made?

A. They were made to be embodied in a caveat and were given to my draughtsman, Mr. S. D. Mott.

12 Q. I now call your attention to the drawing Exhibit F. Do you recognize this drawing?

A. Yes, sir.

13 Q. What is it?

A. It is the last sheet of a caveat drawing.

14 Q. In what respect, if any, does it correspond with the sketches D and E?

168 A. Figure 4 corresponds to Exhibit D. Figure 3 is probably meant to correspond to Exhibit E, lower figure.

15 Q. When was that drawing, Exhibit F, prepared?

A. Probably in January, 1881.

16 Q. I now call your attention to Exhibit G. Do you recognize the same?

A. Yes, sir.

17 Q. What is this exhibit?

A. It is a letter from me to my patent solicitor,

Mr. Dyer, containing instructions for the prepara- 169
tion of a patent application wherein extra brushes were placed upon the commutator, and independently adjustable of the main brushes, the extra brushes being connected with the field of force magnets to energize the same.

18 Q. Who made the sketch of Exhibit G?

A. The sketch and writing are my own.

19 Q. When were this sketch and description prepared by you?

A. February 6th, 1882. 170

20 Q. Did you ever make use of the invention of one or more extra brushes for energizing the field magnet of a dynamo-electric machine, the extra brushes being mounted upon the commutator with the main brushes, and being adjustable independently of the main brushes?

A. Yes, sir.

21 Q. When?

A. Some time between the 1st of February and the middle of May, 1882. I cannot remember ex- 171
actly the time.

22 Q. What was the construction of the apparatus you then used?

A. I think a rough experiment was tried as shown in Figure 2 of Exhibit G.

23 Q. Was any use made subsequently of this invention by you?

A. I think a number of experiments as to the best position of placing the brushes were made in May, 1882. 172

24 Q. Who conducted these last experiments?

A. My assistant, John Ott.

25 Q. I now call your attention to Edison's Exhibit C. Do you recognize the same?

A. Yes, sir.

26 Q. What is it?

A. It is an extra swinging arm for carrying the extra brushes connected to the field of force magnets, and was used on a "Z" dynamo at Menlo Park some time in May, 1882.

173 27 Q. How was this arm mounted in position?

A. It was mounted, I think, over the pillow block of the machine.

28 Q. What mechanical relation did this arm bear to the arm which carried the main brushes?

A. This arm was independently adjustable, that is to say, carried by an arm adjustable independent of the main line brush arm so that more or less current could be made to pass through the field of force magnets.

174 29 Q. Was any further use made of the invention after the use of Exhibit C?

A. A first-class machine was made in which this invention was carried out. The apparatus was connected to a "Z" dynamo. This dynamo was employed by me to light my house at Menlo Park, and the regulator was used for, I should say, two months or more.

30 Q. When was this regulator put into operation?

175 A. I think within a few days from the 1st of June, 1882.

31 Q. What was the construction of this regulator?

A. It consisted of an arm carrying an extra brush which was independently adjustable on the commutator, the brush being connected to the field of force magnet, a movement back or forward on the commutator of this brush increasing or diminishing the strength of current through the field of force.

176 32 Q. How was the extra brush adjusted?

A. By an independent movable arm which was worked by a worm and gear, I think.

33 Q. Was the movement effected by hand or automatically?

A. It worked automatically.

34 Q. I now call your attention to the drawing marked Exhibit B. Do you recognize the same?

A. Yes, sir; I do.

35 Q. What does it represent?

A. It represents an arm which carries an extra

brush resting upon the commutator and independ- 177
ently movable round the surface of the commutator by means of a worm and worm-wheel worked back and forward by means of ratchet wheels and electro-magnets.

36 Q. For what purpose was this drawing made?

A. It was a drawing made for the workmen to make the apparatus by.

37 Q. Was this apparatus constructed?

A. This apparatus was constructed and connected to a dynamo machine and tested, and is the same 178
with the exception, perhaps, of some changes in the automatic mechanism for working the arm back and forward as was used to regulate the dynamo which lighted my house, about which I have already testified.

38 Q. Who made this drawing, Exhibit B?

A. I believe it was made by John Ott, my assistant.

39 Q. Under whose directions?

A. Under my directions.

40 Q. What was the nature of the directions you 179
gave Ott?

A. I explained what I desired to do and gave him the general design of the mechanism and arrangement of the parts.

41 Q. Under whose directions were the experiments on the extra-brush regulator which preceded this drawing, made?

A. I made a great many of them myself, and Mr.
Ott made a number under my direction. 180

Cross-examination by George P. Barton, Counsel for Scribner:

42 x-Q. The machines illustrated in the sketch of Exhibit G, also lower Figure of Exhibit E and Figure 3 of Exhibit F, are all substantially three-brush machines, are they not?

A. Yes, sir.

43 x-Q. Look upon Figures 1, 2 and 3 of your ap-

181 plication-drawing, and state whether or not the machine illustrated by the said figures, is or is not substantially a three-brush machine?

A. They may be considered so.

43 x-Q. Does Exhibit B also illustrate a machine of this same type.

A. It illustrates a machine with a single brush connected to the field of force magnet, the other end of the field of force magnet being connected to the ordinary main line brush.

182 44 x-Q. State whether or not Exhibit D and figure four of Exhibit F and figure four of your application drawing represent another type of dynamos in which the field of force is supplied by the extra brushes independent of any connection with the main brushes?

A. They do supply the field of force magnets independent of the main line brushes, except through the commutator.

45 x-Q. Your experiments made in the latter part
183 of May, 1882, with Exhibit C, were for the purpose of determining whether a machine of this latter type would be a success, were they not? I mean the machine in which the field of force magnet was supplied, independent of any main brush connection.

A. If I remember aright the experiment was to determine which was the best method of taking off the current by one or two brushes.

46 x-Q. What did you conclude from those experiments?

184 A. That one brush only was necessary.

47 x-Q. That is, did you conclude that one brush was superior to two?

A. I do not remember.

48 x-Q. Look at figure three of your application drawing, sheet two. The main brushes are D and D^1, are they not?

A. Yes, sir.

49 x-Q. They are placed so as to include the opposite plates of the commutator, are they not?

A. Yes, sir.

50 x-Q. The third brush F is connected to one side of the field of force magnet and the other side 185 of the field of force magnet is connected to the main brush D^1, is it not?

A. Yes, sir.

51 x-Q. Does it not throw your armature out of balance to connect only on one side and derive a circuit from one side alone in this way?

A. It takes more current off one-half of the armature, but as this armature is revolving with great rapidity the heat is evenly distributed. The only 186 result of taking more current off one side is that there is a slight internal drop of electro-motive force on that side.

52 x-Q. Would it not reduce the resistance of that side of the armature somewhat as compared to the other side of the armature?

A. If it was standing still it would.

53 x-Q. That portion of the armature which is on the side from which the derived circuit is taken is all of the time lower in resistance than the other 187 side of the armature, is it not? Both when at rest and when revolving at a high rate of speed?

A. No, sir; the resistance of the armature is the same, but the resistance of the external circuit connected to that portion of the armature is lower, hence that portion does more work, but as there is over a thousand changes per minute the work, as far as the heat is concerned, is evenly distributed over the whole armature. As the electro-motive force is due to the number of turns on the armature 188 and is independent of the resistance of the same, the electro-motive force is nearly the same, except what is due to the slight drop in the armature itself.

54 x-Q. My point is this, if you are to measure the internal resistance of your machine, making your measurements between the brushes D and D^1, would not the resistance of the half of the machine to which the extra brush is connected be lower than

189 the half where there is no brush connected, as shown in figure 3 of your application drawing?

A. No, sir; for the reason that the exterior circuit does not increase or diminish the resistance of the armature.

55 x-Q. What was the resistance of the field magnets in the experimental machine which you worked in the summer of 1882?

A. The resistance of the field of force magnet of a "Z" machine upon which this regulator worked for
190 lighting my house was about 40 ohms.

56 x-Q. Did you ever work it with a lower field of force resistance?

A. Yes, sir.

57 x-Q. What was the lowest resistance of the field of force magnet you were ever able to work with on a dynamo, the connections of which were like the machine in figure 3 of the application drawing?

A. I do not think it was tried on a dynamo hav-
191 ing a field of force magnet of a lower resistance than 40 ohms.

58 x-Q. What was the probable resistance of your lamps circuit in this case?

A. About an ohm and a half.

59 x-Q. When the third brush, as shown in figure 3, sheet two of your Patent Office drawing, was adjusted to the side of the commutator directly opposite that upon which D¹ rests, the full current of the machine was shunted through the field of
192 force magnets, was it not?

A. Yes, sir.

60 x-Q. About what position did that brush usually occupy on the commutator in the experiments?

A. It would depend upon the number of lamps in the external circuit. It would probably be near the top of the armature, but towards the brush D.

61 x-Q. Did the third brush F ever pass over near the brush D¹ when the number of lamps were very

few in actual practice, or do you remember about 193
that?

A. My impression is that it didn't pass the top of the commutator towards D¹. I do not remember distinctly.

THOS. A. EDISON.

194

195

196

197 STATE OF NEW YORK, }
County of New York, } ss.:

I, WILLIAM H. MEADOWCROFT, a notary public within and for the County and State of New York, do hereby certify that the foregoing depositions of John F. Ott, Martin N. Force, Samuel D. Mott, Richard N. Dyer and Thomas A. Edison, were taken on behalf of Thomas A. Edison, in pursuance of the notices hereunto annexed, before me at No. 65 Fifth avenue, in the City of New York, in said
198 county, on the 3d and 4th days of October, and the 5th and 6th days of November, 1883; that each of said witnesses was by me duly sworn before the commencement of his testimony; that the testimony of said witnesses was written out by Edward H. Pyatt and Frank McGowan, in my presence; that the opposing party, Chas. E. Scribner, was present during the taking of the testimony, in person and by his counsel, George P. Barton, Esq.: that the opposing party, Richard H. Mather, was
199 present during a portion of the testimony, by his counsel, Chas. L. Burdett, Esq.; that said testimony was commenced at 11 o'clock A. M. on the 3d day of October, 1883, and was continued pursuant to adjournment and further notice on the 4th day of October and the 5th day of November, and was concluded on the 6th day of November, 1883; that I am not connected by blood or marriage with either of the parties to the interference or interested directly or indirectly in the matter in controversy.
200 In testimony whereof, I have hereunto set my hand and affixed my seal of office, at the City of New York, in said county, this 15th day of November, 1883.

[SEAL.] WM. H. MEADOWCROFT,
Notary Public,
New York County.

STATE OF NEW YORK, }
County of New York, } ss: 201

I, WILLIAM H. ALDEN, JR., a Notary Public, within and for the County and State of New York, do hereby certify that the foregoing deposition of William H. Meadowcroft was taken on behalf of Thomas A. Edison, in pursuance of the notices hereto annexed, before me, at No. 65 Fifth avenue, in the City of New York, in said county, on the 4th day of October, 1883; that said witness was by me duly sworn before the commencement of his testi- 202
mony; that the testimony of said witness was written out by Edward H. Pyatt in my presence; that the opposing party, Chas. E. Scribner, was present in person and by his counsel, Geo. P. Barton, Esq., during the taking of said testimony; that the opposing party, Richard H. Mather, was absent; that said testimony was commenced and concluded on the 4th day of October, 1883; that I am not connected by blood or marriage with either of said parties, or interested directly or indirectly 203
in the matter in controversy.

In testimony whereof, I have hereunto set my hand and affixed my seal of office, this 15th day of November, 1883.

WM. H. ALDEN, JR.,
[SEAL.] Notary Public (63),
N. Y. Co.

204

Edison's Exhibit G, November 5, 1883.

Wm. H. Meadowcroft, Notary Public, N. Y. Co.

PATENT.

Dick—Please write up the specifications for this patent, and keep it until I get in.

Method of deriving two independent circuits from a dynamo or magnetic electric machine, each of which has a different electromotive force regulatably independent of each other. Such extra circuit useful for working the field of force magnets or the field of force magnets mulliple-arc'd across a circuit containing lamps requiring lower volts or emf.

X is the bobbin; C and C¹ are the regular brushes; 1 and 2 the regular circuit across which lamps requiring the highest volts are placed. a b are extra brushes one above the centre the other below the centre; say several blocks to the right and left of C. These brushes are connected to an arm, and are swung around by the handle, the brushes being pivoted as well, the handle may be worked so the brushes a c are brought in line with C, or by putting handle at angle separated when a and b are furthest from the centre or line or block upon which C rests, there is the greatest electromotive force; these two brushes a b are connected together, forming one pole of the second circuit, while C forms the other pole.

a and b when connected together do not short circuit the wire on the machine as both sides of the bobbin, are sending currents in the same direction. Fig. 2 shows the two arms on separate swings, so they may be brought to or from the centre independently.

February 6, 1882.

T. A. E.

IN THE U. S. PATENT OFFICE.

Interferences: Magneto Electric Machines.

BEFORE THE EXAMINERS-IN-CHIEF.

Case A	Case B
EDISON *vs.* LANE *vs.* GRAY *vs.* ROSE *vs.* GILLILAND.	EDISON *vs.* LANE *vs.* GRAY *vs.* EDISON & JOHNSON.

BRIEF FOR EDISON.

THE ISSUES.

Case A.

The combination of a main circuit and a dynamo or magneto electric machine, with a shunt or short circuit around the machine, and means for automatically controlling and breaking such short circuit immediately upon and continuously during the operation of the machine.

Case B.

The combination of a driving shaft of a dynamo or magneto electric machine, a sleeve mounted thereon in such a manner as to have a determinate longitudinal movement thereon, and a circuit breaker automatically operated by said longitudinal movement of the sleeve.

Neither of the contestants show a sleeve mounted directly upon the shaft of the armature, or a sleeve having a longitudinal movement thereon: but each shows a sleeve mounted and having longitudinal movement upon a driving shaft, connected more or less closely with another shaft upon which the armature is mounted.

In Case A, Edison, Gray and Gilliland have taken testimony, and Lane and Rose having failed to take any, their respective dates of invention are fixed by their date of filing, which in Lane's application was January 8, 1881, and in Rose's application, November 5, 1880.

In Case B, neither Lane or Edison & Johnson have taken any testimony, and accordingly January 8, 1881, is the earliest date for Lane, and October 6, 1880, the earliest date for Edison & Johnson.

In these cases the Examiner of Interferences awarded priority to Gray. Edison has appealed. None of the others have done so, and the contest is now solely between Edison and Gray.

Gray's Proofs.

Gray is a party to both cases, A and B.

His proofs disclose that he conceived his invention in both cases in October, 1878, and then explained it to others; had two complete working models made, one of which is Exhibit A, which were completed November 13, 1878, and experimented with and used successfully soon afterwards, and then laid aside until a public demand arose, which was in the fall of 1880, when manufacture was commenced and carried on extensively by the Western Electric Manufacturing Company.

Gray's date of invention then may be assumed to be October, 1878.

Edison's Proofs.

Edison is a party to both cases, A and B.

His proofs disclose as to Case A, a working apparatus made in 1872, and produced as exhibit "Signal Box," and put in use experimentally at that time, and then laid aside until a public demand arose, and then taken up in July, 1880, and a manufacture commencing then, and continued thereafter to a limited extent.

As to Case B, his proofs disclose a caveat filed May 11, 1871, and a patent No. 123,005, granted January 23, 1872, covering substantially the issue in this case, and the same laying aside and taking up, and manufacture as in Case A.

From the foregoing summary it is evident that in both cases, A and B, Edison is called upon to prove a date of invention earlier than October, 1878.

Case A.

To make this proof in this case, Edison presents:

1. The model exhibit "Magneto Signal Box," made in 1872, with the attachments reproduced in dotted lines in "Exhibit No. 2." This last named exhibit, as compared with the issue, shows in combination, a main circuit 3, 3, a reciprocating magneto electric machine, A. E. M., a shunt or short circuit 1, 2, around the machine, and means H. X. N. V. 2, for automatically controlling and breaking such short circuit immediately upon, and continuously during the

operation of the machine. It shows the precise combination of the issue operating in precisely the same way, and with precisely the same result as called for by the issue.

Magneto Cases.

It was urged in argument in behalf of Gray at the hearing below:

I.

That there is no proof that Edison invented this exhibit, Magneto Signal Box, to which it is answered:

1. Mr. Edison swears that he made the invention in issue in 1871, (answer 2;) that he has an instrument made in 1872 which meets the issue, (3;) that it was made at his shop, (6;) that it was made from sketches and partially under his supervision, (7;) that it has been in his possession ever since, (22;) (Kruesi, 34;) (Ott., 3, 7, 10, 12, 13, 16, 18;) (Force, 4, 7;) (Wurth, 8, 19.)
2. And there is not a particle of presence by any witness that it was not the invention of Mr. Edison.

II.

While it was not denied that this exhibit in its complete form covered the issue in this interference, it was contended strenuously that the exhibit would not work, either with the spring, T, or without, for these reasons, viz:

If the spring, T, is used, the lever, H, upon being released, would immediately be drawn back against the stop, O, cutting out the box by shunt wire, 1, which would cut off the signal before it was entirely sent.

If the spring, T, is not used, the lever, H, being permitted to return slowly, the character wheel would stop, not at click, CC, but at any point wherever the spring, SS, might run down. The result would be an improper signal.

As this matter evidently has great weight in the mind of the counsel for Gray, and seems to have impressed the Examiner of Interferences, it is proper to answer it somewhat in detail.

1. It is to be noticed that Mr. Edison first on examination in chief, called attention to this spring, T, and stated its defects, and consequently its prompt removal, (a. 34.)
2. Mr. Edison's testimony is that with the spring, T, a signal would be sent, but the signalling was not long enough, (a. 34.)
3. With the spring, T, removed, Mr. Edison swears that the signal would be fully sent, (a. 34;) that "it operated perfectly," (a. 14.)
4. The point made by counsel below, that without the spring T the character wheel would stop at any point wherever the spring S S might run down, is answered by the statement that the spring S S was a clock spring, with the capacity to move the handle over a much larger area than required, that the downward movement of the handle wound up the spring to a certain extent, and its unwinding carried up the handle as far as desired, and the spring could not run down, and if the instrument does not operate perfectly now it did so at the time the evidence was taken, and at the hearing below.

In conclusion, upon this point, it is urged that the issue does not call for a signal box, or a box to transmit certain signals, or for anything but a short circuit around a dynamo or magneto electric machine, which has a main circuit and means for automatically controlling and breaking the short circuit immediately upon and continuously during the operation of the machine.

The evidence is clear that the "magneto signal box" has all the elements in the issue, operating in the way and for the purposes described in the issue, and it is a matter of no consequence if the operation was not so perfect as in subsequent instruments.

As a matter of fact, the "magneto signal box" embraced the issue, whether the spring T was or was not upon it. Mr. Edison removed that spring to make the operation better for a particular purpose.

5. As to the objection urged in argument below, that the terms of the issue, viz., "dynamo or magneto electric machine," do not embrace such an electric machine as that shown in Exhibit 2, it is answered:

Gray uses an armature which revolves in front of an electro magnet connected with a battery. Edison uses an armature which reciprocates in front of an electro magnet connected with a permanent magnet.

Both instruments operate by electrical force, in substantially the same way, and produce identically the same results, and it requires no invention to substitute one for the other.

6. Furthermore, it is now understood, and accepted in the Patent Office, that the terms "dynamo or magneto electric machines" include all kinds of electrical generators or motors—any electrical machine which has capacity as a generator, having also capacity as a motor—and the term dynamo being applied to all electrical machines which excite their own current, and the term magneto electric being applied to all electrical machines where the electric energy is supplied from an external source.

7. In answer to the possible objection that the exhibit instruments of Edison and of Gray were not intended for the same purpose, it is urged that the purpose is no part of the issue, and even if it had been otherwise, the purposes of the two instruments are strictly analogous.

III.

It was also urged in argument below, and the argument seems to have impressed the Examiner of Interferences, that this exhibit represents only an abandoned experiment, be-

cause it has been largely broken up, and because it was laid aside so long.

To this it is answered—

1. As a matter of fact the missing parts (all shown in Exhibit No. 2 in dotted lines) are simply ordinary electric wires and ordinary permanent magnets, a vibrating lever armature, the spiral spring T, and the box or shell.

The instrument itself, in its present form, indicates that it had all of these parts. There is no question made by the evidence that it had all of these parts.

2. Neither is there evidence that the apparatus was broken up, in the usual sense of the word. Edison swears that the missing parts were mislaid, and he has been able to find only one of the magnets, (a. 3, 22.) Wurth swears that he withdrew the magnets for "other experimental work" late in the summer of 1876, (a. 13, 14,) and the box and binding posts were then in order, (a. 23.)

3. The removal of these parts (and it does not appear that it was with the knowledge or consent of Mr. Edison) was not such a breaking up as would indicate the idea of abandonment, and Mr. Edison's testimony is clear and conclusive that he never intended to abandon it, (a. 20.)

IV.

It was insisted in the argument below that the only evidence about the removal of the spring T proceeded from Edison, and that he is contradicted by his other witnesses.

To this it is answered—

1. That Edison swears positively to the fact and its circumstances, (34.)

2. Kruesi simply swears that he sees no difference between Exhibit 2 and the instrument as he saw it complete in 1873, (71.)

3. Ott swears that he saw it in 1879, and the lever X was

in it then, (18,) and to the best of his recollection all the other parts.

4. Force only remembers about the box with its handle, and about one of the magnets.

5. Wurth remembers particularly about the box and its handle, and the magnets which he removed.

Not one of these witnesses had his attention directed to the spring T, and the question is only as to a single detail, of which Mr. Edison has a perfect recollection and the other witnesses an imperfect recollection.

4. The evidence is clear and positive that Edison as well as Gray took up these instruments afresh, as soon as the public was ready for them; one after a delay of two years, and the other after a delay of six years, during which time no adverse right arose calling for the exercise of greater diligence than that exhibited.

5. It follows, therefore, that Edison having produced the invention in issue in 1872, having then put it in material form and demonstrated its capacity to do its work, and having never abandoned it, and having taken it up before other rights intervened and as soon as public demand would warrant, and having been the first to manufacture and prompt in making application, is entitled to go back to 1872 as his date of invention, and is entitled to an award of priority, in Case A, over all other contestants.

Hockhausen *vs.* Weston, 18 O. G., 857.

Case B.

Here the claim is of a limited character, embracing features of construction adapted to produce a longitudinal movement of a sleeve or collar upon a driving shaft of an electric machine for the purpose of operating a circuit breaker.

GRAY'S PROOFS.

In this case, as in Case A, he appears to have made the invention in October, 1878.

EDISON'S PROOFS.

In 1870 he devised a printing telegraph, upon which he filed a caveat May 11, 1871, (in evidence,) which describes and illustrates broadly the combination in issue employed in an electro magnetic machine, used as a motor.

In 1872 he obtained a patent, No. 123,005, (in evidence,) when the circuit breaker was operated by the longitudinal movements of a sleeve upon a driving shaft, which patent also describes and illustrates this portion of the invention described and illustrated in the caveat, and covers broadly the issue in this case as employed in an electro magnetic machine, used as a motor.

In the caveat, as well as in the patent referred to, the sleeve is mounted upon a shaft, and the connection with the electro magnetic machine is more remote than in the applications in controversy.

On October 6, 1880, Edison and Johnson filed a joint application which is embraced in this interference, and on September 19, 1881, Edison, discovering that this application covered only what was his sole invention, filed a sole application, which is embraced in this interference.

Edison's date then of seeking protection for his invention therefore really goes back to October 6, 1880. Upon another joint application of Edison and Johnson, filed November 11, 1880, a patent was granted to them February 22, 1881, No. 238,098, and this patent covers what was the actual joint invention of Edison and Johnson, viz., an improvement upon the invention described in Edison's sole application, and in the erroneous joint application of Edison and Johnson, filed October 6, 1880.

In July, 1880, Bergmann, by permission of Edison, commenced the manufacture of telephone call-boxes, embracing the issue in this case, and directly thereafterwards manufactured and sold between four and five hundred of them.

In this case it was argued below, not that the caveat and patent introduced by Edison did not broadly answer the

issue, but that they were motors and not generators, and for a different purpose than the instruments in controversy, and the Examiner of Interferences bases his decision on precisely those grounds.

To this it is answered—

1. That the invention made by Edison, and described and illustrated in his caveat of May 11, 1871, and in his patent No. 123,005, of 1872, cover substantially the combination in this issue.

The only differences are, that the earlier inventions of Edison were for telegraphic purposes and not for telephone call-boxes, and that he employed electric motors instead of electric generators, and that the shaft upon which he placed his sleeve was not connected so intimately with the armature shaft, but the mode of operation and the result was the same, and effected in the same way.

2. The issue does not, however, define or include the uses for which these inventions are applicable. The inventors themselves give different titles to their inventions, and the Patent Office still another title. Edison does not describe any uses for his invention.

The principal difference between the inventions described and illustrated in Edison's caveat and patent before mentioned and the invention in issue being the employment of an electrical machine as a motor, and not as a generator, in connection with a circuit breaker, no change of construction being involved in their change of employment, there is in this respect no invention at all, and Edison's caveat and patent would cover the issue in controversy.

The other difference, being the employment of a sleeve upon a driving shaft to operate a circuit breaker, which driving shaft is connected with the armature shaft more remotely than is done in the pending applications, is only a question of degree, and is not of itself patentable.

3. If it should be concluded that the issue is a patentable combination in view of Edison's caveat and patent before

mentioned, still Edison has the right to claim back to 1872, when he produced the generic invention, provided that he did not abandon the same, and took up and completed the invention before other rights intervened, and as soon as the public demand called for it.

4. Edison was not called upon to exercise any diligence at all before the public had some intelligence of such an invention, and that was evidently by the manufacture by Bergmann of Edison's own invention in July, 1880, and after this public knowledge Edison used lawful diligence in applying for a patent.

The contemporaneous introduction of the invention by Edison, Gray, and Gilliland, in 1880, and for the same reason that there was then first a public demand, is conclusive of this fact.

5. As between these contestants Edison was the first to make the invention, considered broadly, and the first to introduce it to public use.

He had the right to take up his invention of 1872 in the same line of inventions, and make in 1880 such changes in the arrangement of his former elements as brought them precisely within the terms of this issue and retain his original date of 1872.

And this has virtually been lately decided by the Commissioner of Patents in the case of Weston *vs.* Gray *et al.*, (not printed.)

Conclusion.

1. As to case A, Edison was the first to produce the invention in controversy, and is entitled to a judgment of priority over the other contestants.

2. As to case B, it is questionable if the issue discloses any invention at all in view of Edison's caveat and patent before mentioned.

3. If, in view of the same caveat and patent, the issue

presents a patentable combination, Edison was the first to produce broadly, and has a right in law to go back to the date of his original invention to support his new arrangement of elements, and, so going back, is entitled to an award of priority over the other contestants.

GEO. W. DYER,
For Edison.

WASHINGTON, D. C., *February* 22, 1882.

BURGOYNE (Telephone No. 590), 29 Rose St.

IN THE MATTER OF INTERFERENCE

BETWEEN THE

APPLICATIONS OF THOMAS A. EDISON AND HENRY C. NICHOLSON, FOR LETTERS PATENT FOR IMPROVEMENTS IN DUPLEX TELEGRAPHY.

Appeal to the Secretary of the Interior from the decision of the Commissioner of Patents, refusing to Thomas A. Edison permission to amend his preliminary statement.

Brief in Behalf of T. A. Edison.

May it please your Honor:

This application for leave to amend the preliminary statement, was made by Edison after Nicholson had taken his evidence, and before offering evidence in his own behalf, and it was presented with affidavits distinctly setting forth the character of the amendment sought, and the reasons why the subject matter of the proposed amendment was offered at that stage of the proceeding and not earlier. The motion to amend was made with all the formality required by the rules of the Patent Office, and was presented regularly, first, to the Examiner of Interferences, then, upon his refusal, by appeal to the Commissioner of Patents.

The rules of the Patent Office in such cases as the present provide for the appeal from the Examiner of Interferences directly to the Commissioner of Patents, but do not provide for an appeal from the Commissioner to the Secretary of the Interior, and hence the first objection made to this appeal by Nich-

elson is, that the Secretary of the Interior is without jurisdiction in the premises, and that, therefore, the appeal must be dismissed, and his attorneys have made a motion to that effect. Before proceeding to answer this asserted want of jurisdiction, it may be well to notice the fact that whilst the said Nicholson founds his motion to dismiss upon the want of jurisdiction of the Secretary to inquire into the merits of the application to amend, in view of rules of practice approved by Hon. Secretary of Interior, and he also bases it upon an alleged inaccuracy of statement of the facts in the case, and of the decision of the Commissioner. He thus denies jurisdiction and then asks your Honor to decide whether the facts are not incorrectly set forth, which, of course, involves an inquiry into the whole case before it could be dismissed. Either the Secretary has jurisdiction or he has not. If he has jurisdiction in the enactment of rules, he certainly must have in their interpretation and enforcement. If there is any inaccuracy of statement in the appeal petition, the Hon. Commissioner of Patents has not discovered it, and it is supplemented and corrected by the record, and if the Secretary of the Interior has no jurisdiction, then it would be idle to go into the facts of the case, to ascertain whether the second ground of the motion to dismiss were well or ill founded. But is the Secretary of the Interior without jurisdiction? Jurisdiction has been well defined to be judicial power. And if it be found that the Secretary has supervisory and revisory power over the acts of the Commissioner of Patents, it must necessarily follow that he has jurisdiction in this matter, unless this supervisory power, if given, is limited by some statutory restrictions which would preclude its application.

We do not pretend to deny, that in judicial proceedings, it is a well established rule, that where a matter is submitted to the discretion of a tribunal, and that tribunal exercises its discretion and renders a decision, that such decision is final, and that from

it no appeal will lie. But we do say, that in this matter, a question of absolute right, assured by statute, and the recognition of which is rendered obligatory upon the Commissioner by the same statute, is at issue, that it is not a mere discretionary matter with the Commissioner, and that therefore an appeal should ordinarily lie from adverse action. And we further say, that there is no perfect analogy between the relations of the Secretary and Commissioner and those of an appellate and lower Court, as is fully manifested upon examination of the patent laws, and that, therefore, the rules that limit and restrict the powers of an ordinary appellate tribunal should not be applied in ascertaining the extent of the jurisdiction of the Secretary.

What are the relations of the Secretary of the Interior to the Commissioner of Patents?

Referring to a few sections of the Revised Statutes of the United States, we find, in section 475, that there shall be *in* the *Department* of the Interior an *office* known as the Patent Office; in section 476, that all the officers except the Commissioner and Assistant Commissioner of Patents and the Examiners in Chief, shall be appointed by the Secretary of the Interior upon the nomination of the Commissioner of Patents; in section 481, the Commissioner of Patents, *under the direction of the Secretary of the Interior*, shall superintend or perform all duties respecting the granting and issuing of patents directed by law; in section 483, the Commissioner of Patents, *subject to the approval of the Secretary of the Interior*, may, from time to time, establish regulations not inconsistent with law; in section 487, the Commissioner may refuse to recognize an attorney, *subject to the approval of the Secretary* of the Interior.

It is apparent from these sections, and others that might be referred to, that the Commissioner of Patents is subordinate to the Secretary of the Interior, and that he merely superintends and directs a bu-

reau of the Interior Department, under the direction and subject to the approval of the Secretary. The Secretary has the statutory right of supervision and control over all of his official acts, and peculiarly and specially so of his acts affecting the granting and issuing of patents, for section 481 provides that "under the *direction* of the Secretary of the Interior," the Commissioner "shall superintend or perform all duties respecting the granting and issuing "of patents directed by law," &c. We therefore submit, that it can not admit of a doubt, that the Secretary of the Interior is, by the law, clothed with the *power* to approve, or disapprove, to ratify, rescind, or modify any action of the Commissioner of Patents respecting the granting and issuing of patents, and that being so, that he has the same power over any action of the Commissioner of Patents, that, in any stage of an application for a patent affects the right to a patent, and especially of an action based upon the misconstruction of a technical rule of practice, which threatens to deprive the inventor of rights intended to be secured to him by the statute. It needed no rule of practice to bestow upon an applicant for a patent, in interference or not in interference, the right to invoke the supervisory power of the Secretary of the Interior. *The statute creates the right by imposing upon him the duty of supervision and direction.*

As we have before stated, it is not a question of appellate jurisdiction in its ordinary sense, nor is it more than very slightly analogous to it. Furthermore the Commissioner of Patents recognizes the propriety of the present appeal by putting in his answer and not questioning the jurisdiction of the Secretary of the Interior in the case.

If the Secretary of the Interior has jurisdiction to hear and determine this application, is it proper and right that the action of the Commissioner of Patents in refusing to permit the amendment to be made to the preliminary statement should be overruled?

It is said by the Commissioner in his reply to this proceeding, referring to the requirements of rule 110, that he "cannot conceive that it was *impossible* for any and every correction necessary to "have been made before the taking of any testimony. The fact that such attention was not "given to the case is quite clearly shown by "the affidavit of Mr. Serrell filed with this "motion." He further states that there are cases in which an amendment ought to be permitted even after testimony taken, and mentions cases in which it would be physically impossible for the applicant making the statement to have by him all the data from which to make it up. He evidently regards the rule as negativing this privilege of amendment, in all cases in which there was a *physical possibility* of making the correction before taking testimony. And if his reasoning is good and his conception of the rule correct, wherever a party making a preliminary statement has in his possession or control all of the data from which a correct statement can be made, and he overlooks and omits some fact from his statement that by the exercise of diligence he *might* have inserted, notwithstanding the fact that it was a "material error," "arising through inadvertence or mistake," and "its correction is *essential to the ends of justice*," he is forever debarred from the privilege, for "negligence ought "not to be rewarded" "nor regarded with special "favor."

Now, if the Commissioner has correctly interpreted the rule, the rule should be abrogated by the Secretary of the Interior as "inconsistent with law," for the only authority conferred by statute upon the subject of such rules is the Sec. 483 before referred to, which provides that "the Commissioner "of Patents, subject to the approval of the Secre-"tary of the Interior, may from time to time "establish regulations NOT INCONSISTENT WITH "LAW, for the conduct of proceedings in the "Patent Office," and the rule so inter-

preted is not only "inconsistent" with the common law regulating practice in judicial proceedings, but of the patent law, which requires that if in an application for a patent "it shall appear that the claim-"ant is justly entitled to a patent *under the law*," the Commissioner shall issue a patent therefor, and in interference cases that the *question of priority shall be determined* and a patent granted to the first inventor. If that interpretation is correct, then every application to amend, although conclusively shown to have arisen through "inadvertence or mistake," to be entirely free from fraud or bad faith, and to be for the correction of a matter "es-"sential to the ends of justice," must be subjected to and determined by the measure which the Commissioner of Patents would apply to the degree of diligence and care that, in his judgment, had been exercised in the preparation of the preliminary statement. In other words, it would subject all such parties and their rights to the caprice of the Commissioner, a consequence to be avoided if possible, however fairly and impartially disposed he might be.

But we do not think that the rule is to be so understood. It is to be taken as a whole, not in segregated sentences, and is to be construed in accordance with the beneficent purpose it was intended to effect, viz., to further "the ends of justice." It relates solely and exclusively to errors that have arisen through "*inadvertence* or *mistake*," and provides that *whenever discovered*, even if after testimony has been taken, the statement *may* be corrected on motion, only so far as he is concerned, "upon "showing to the satisfaction of the Commissioner "that its correction is essential to the ends of "justice." The latter clause of the rule is to be taken with the first, and read thus: "The motion to "correct the statement (for error arising through "inadvertence or mistake) must be made, if possi-"ble, before the taking of any testimony, and *as* "*soon as practicable after the discovery of the* "*error*." After the discovery of the error, the motion to correct must not only be "made, *if possi-*"*ble*, before the taking of any testimony," but "as "soon as practicable." The motion could not be made until the error is discovered, whether it occur either through inadvertence or mistake, and to hold, that by the proper use of care, and diligence the error *might* have been avoided in the first instance, or have been discovered before the taking of any testimony, and, therefore, to deny the right of amendment, is to hold all men to the requirements of a perfection standard, and to deprive the rule of all force and effect. We say that the rule means to, and does give the absolute right to amend, whenever an error has been discovered that has arisen through inadvertence or mistake, whether before or after testimony taken, and upon a motion made to amend as soon as practicable after the discovery of the error, conditioned only upon showing to the satisfaction of the Commissioner *that its correction is essential to the* ENDS OF JUSTICE.

The Commissioner admits that "it is true in this "case, as in every case, that the patent should issue "to the right party." He does not pretend to say that the correction is not "essential to the ends of justice," or that the error did not arise "through inadvertence or mistake," or that the motion was not made "as soon as practicable after the discovery of the error." He simply says that "where proper "cases are presented for the liberal administration "of such rules, undoubtedly they should receive a "liberal construction, but such liberal construction "should only be given when good and sufficient "grounds are shown, not the mere negligence of "parties."

So that, merely because in his judgment the error might, with diligence and care have been sooner discovered, he denies to Mr. Edison a right granted him by the rule, to which he is absolutely entitled, as the Commissioner's reply shows, and, in so doing, he necessarily amends the rule by adding his entirely

unauthorized requirement, that those who seek the benefit of the rule must show that they have not been negligent in hunting out a matter which they did not know existed until they discovered it. He imposes a condition not found in the rule, that he who seeks its benefit must show that his case is entirely free from negligence.

It is believed that the duties of both Mr. Edison and his counsel are as numerous and arduous as those of the Commissioner of Patents, and that to give opportunity to rectify an error or inadvertance would not be "rewarding negligence" in one case more than the other.

Inadvertance is defined as "inattention—negligence" in Webster, and the Commissionér makes a distinction that is unauthorized. The rule allows for amendments that are proper for the ends of justice where there has been inadvertance or negligence, as distinguished from intentional inaccuracies.

The Commissioner admits that in judicial proceedings amendments are allowed upon terms, and it is therefore deemed unnecessary to refer to text books or to decided cases, to enlighten that question generally. There is no doubt that in proceedings at law the general rule is, that, *at any time before verdict, all such amendments may be made as may be necessary for the purpose of determining the real question in controversy between the parties.* That in proceedings in equity, amendments to bills and answers are allowed with liberality, and especially where the subject matter of the amendment depends upon written instruments omitted by accident or mistake. The refusal of permission to amend, therefore, is inconsistent with what may be termed the common law relating to amendments.

It is further urged that the object of the examination of applications for Letters Patent is primarily the protection of the public, and that the object of the interference proceedings in the Patent Office is not only the same, but also, do justice between con-

flicting claimants, by determining the question of priority of invention, and by permitting a patent to be issued to whomsoever is proven to be the first inventor, and that no rule should be made or so interpreted as to abridge or impair those objects. There can be no doubt that if the evidence sought to be used in this proceeding would be sufficient, if admitted, to prove that Edison was the prior inventor, if excluded, and a patent issued to Nicholson, it would be sufficient in a judicial proceeding affecting the validity of such patent to avoid it. The exclusion from consideration in this interference of the new matter sought to be introduced, would be a useless thing, and surely the time of the Patent Office, and the money of the applicants should not be frittered away in useless proceedings.

The Commissioner's reply alleges as an additional ground for refusing permission to amend, that he cannot impose such terms as could be imposed by a Court under similar circumstances.

This objection, if legitimate in any case of application to amend, would not apply to this interference, as the costs of both parties are paid by the Western Union Telegraph Company, which has directed this appeal to be taken because it is of vital importance that the question of priority should be so decided that the patent when granted will be to the first inventor, and the exclusion from the interference of legal evidence would be to tie the hands of the tribunals that decide the questions of priority of invention, and to run the risk of the issue of a patent that would not be sustained by the Courts.

We therefore submit that the Commissioner of Patents has denied to Edison a right assured to him by the law and the rules of the Patent Office, that his action is subject to the revision of the Secretary of the Interior, and that it ought to be reversed, and the leave to amend the preliminary statement be granted.

If the evidence sought to be introduced is legal evi-

dence bearing upon the question of the origin of the invention in controversy, then it would be illegal to exclude the same upon the technicality that it is not in accordance with the preliminary statement. If it is not legal and reliable evidence, it will be excluded on its own lack of reliability. No person will be injured by the preliminary statement being amended, the amendment will not determine the reliability of the evidence, it will only prevent a technicality in the determining of the actual issues of the case.

It is therefore desired that your Honor so interpret the rule in question, or amend it if necessary, that legal evidence shall not be excluded from an interference on the *simple technicality* of its being inconsistent with the preliminary statement.

Rule 105 sets forth that "the parties will be strictly held in their proof to the dates set up in their statements." This rule becomes a bar to the consideration of any evidence that varies the least from the preliminary statement, hence the importance of the granting of the motion for leave to amend the preliminary statement, and it is believed that the Patent Office is to be regarded as a tribunal that is to be governed by considerations of equity, and as the United States Courts are not bound by the preliminary statement of an inventor, the Patent Office MUST permit such changes in the preliminary statement as will secure a decision of the question of priority upon the same lawful evidence as could be availed of in the U. S. Courts, where the same questions arise relative to the patentee being the original and first inventor.

Appended hereto will be found a copy:

1st. Of the motion for the permission to amend the preliminary statement.

2d and 3d. Affidavits of T. A. Edison and L. W. Serrell, accompanying the motion.

4th. Decision of Examiner of Interference.

5th. Appeal to Commissioner of Patents in person.

6th. Grounds of Commissioner for denying the motion.

7th. Appeal to Hon. Secretary of the Interior.

8th. The answer of Hon. Commissioner of Patents to the said appeal.

From these the whole facts and reasons involved in the present case will be apparent, and upon these it is believed that the equity and propriety of the motion must be apparent.

It is proper to enter an answer to the argument of counsel for Nicholson in the motion made to dismiss the appeal of Edison to the Secretary of the Interior.

It will be observed that the Commissioner of Patents did not assign any reasons for his adverse decision, he simply affirmed the action of the Examiner of Interferences; he did not even intimate that it would be contrary to the ends of justice to grant the permission to amend the statement, neither did he intimate that the evidence was unsatisfactory to him, and neither of these intimations are contained in his answer to the present appeal, hence the principal and proper grounds of appeal to the Secretary of the Interior are that the Commissioner has acted contrary to the rules established by the Department, and has, in substance, changed those rules without authority, and thereby opens the door for the commission of an illegal act, viz: the exclusion of legal evidence and the possibility of a wrong decision being arrived at, and the granting of an invalid patent.

It is to be regretted that counsel for Nicholson have drawn into this controversy a proceeding (Edison and Harrington vs. Edison and Prescott) with which our client Edison had nothing to do except in name. As it has been brought in, your Honor should be briefly informed of its nature: It was an effort on the part of Harrington to show that certain patents should be issued to him as assignee, instead of to Prescott as assignee jointly with Edison; it was an effort to induce the Commissioner of Patents to act as a judge to determine the question of the title

of rival claimants by assignment. It requires but a glance to see that this question of ownership was and is entirely outside of the Patent Office and the Department of the Interior. The law gives no jurisdiction in such cases, and the proceedings in the case should never have been entertained for a moment, and as there are no points of similarity in the questions involved, nothing more need be said.

In some of the cases cited, it will be found that the decisions related to what was legal evidence, and they were based, not on the interpretation of the rules of practice, but upon the merits of the evidence itself that was presented, and the legality of the same.

If the Secretary of the Interior has the power to revise rules, he must certainly have the power to prevent them being interpreted or enforced in an illegal manner.

In some cases cited by counsel for Nicholson, the decision of the Secretary was just the reverse of that which counsel contends, as will be seen from the following extracts:

In the case of F. H. Hunt, O. G., vol. 13, p. 772, the Secretary of Interior said:

"I therefore direct in all cases which may hereafter arise where, for any reason, you may deem it improper to complete the issuance of a patent after it has been signed, that you forthwith transmit the same to this Department, with all the papers in the case, before taking further action therein, with your reasons for declining to complete the issue of such patent for consideration and instruction."

And in the case of Sargent, O. G., vol. 12, page 477, he said:

The Commissioner of Patents is to "superintend or perform all duties respecting the granting and issuing of patents," but these duties are to be performed "under the direction of the Secretary of the Interior."

"If the Commissioner neglects or refuses to perform any required duty by law to be performed by

him, under the direction of the Secretary of the Interior, or performs a ministerial or administrative duty improperly, I am of the opinion that the Secretary of the Interior, by virtue of his supervisory power, may direct him in its performance. To be charged with the responsibility of the supervision and direction of any kind of work or business by law, and not be able to require that it shall be in accordance with the law, would be anomalous indeed."

"But it is said that if the Commissioner of Patents neglects or refuses to perform any duty required of him by law, the Court will compel him by mandamus to perform it. Supposing this to be so, does that lessen the obligation and responsibility on my part in such a case, if I am called upon to see to it that the law be executed? The fact that a Court which is charged with the duty of protecting all persons in their rights, will, when the facts are presented to it, grant such a writ, in no way relieves me the duty of making a proper order for the performance of the same thing, where the work to be done is in the hands of an officer who performs all of his duties under my direction and I am charged with the responsibility of seeing that that work is properly performed."

"If I am correct in this conclusion, and I see no escape from it, then it is clear that I have the right to direct the Commissioner of Patents in the performance of all administrative or ministerial duties."

It is the height of folly for counsel to complain that there has been long delays in determining the rights of Nicholson, and at the same time suggest that if, through the exclusion of legal evidence on a technicality, the patent should be granted to the wrong party, it might be rectified by a bill in equity. Such a proceeding would only still further postpone the determination of the rights of the respective parties, and it is only a suicidal policy on the prat of Nicholson and his counsel that has led them to oppose the amendment of Edison's preliminary

statement, and they alone are responsible for this delay, and if the patent should be granted to the wrong party by the persistent refusal of the Patent Office to admit legal evidence, and a bill in equity has to be resorted to, it may be prophesied that there will be a similar outcry against delay, and a similar failure to see that the delay is chargeable to Nicholson's *own* counsel.

The question of the origin of the invention does not come before the Secretary of the Interior; he is not asked to decide any matter of interference: the matter of this appeal is simply in relation to the legality of a rule and its mode of interpretation. The statute (sec. 4904) requires that the question of *priority of invention shall be determined, and any rules or proceedings which prevent this being done are illegal and must be set aside;* and the only question that has to be decided is, whether Edison can be excluded from introducing legal evidence. Whether the evidence is legal or not is not under discussion; that comes up when the merits of the case and the reliability of the testimony is under discussion, and all that the Secretary of the Interior need to say is, that the rules concerning preliminary statements are not to be so interpreted as to exclude from the hearing legal evidence on the question of priority of invention, and to this extent the Secretary of the Interior certainly has jurisdiction as the head of the Department and under whose supervision the rules are enacted. We do not ask the Secretary to decide what is legal evidence; that can be safely left to the authorities having power to determine interferences, but we do respectfully insist that to allow rules to be interpreted so as to give opportunity to exclude legal evidence is illegal and cannot stand in the face of the express statute, and the fact that the Patent Office is a tribunal presumed to be based on the principles of equity, having power to determine the question of priority of invention in an

intelligent manner, and to grant the patent to the man whom the legal evidence shows is entitled to it.

Respectfully submitted,

LEMUEL W. SERRELL.
ANDREW C. BRADLEY.
For T. A. Edison.

No. 1.

IN THE MATTER OF INTERFERENCE.

THOMAS A. EDISON
AGAINST
HENRY C. NICHOLSON.
Improvements in Telegraphs.

NEW YORK, Nov. 29, 1880.

DR. H. C. NICHOLSON:

SIR--Please to take notice that upon December 15th, at 12 noon, and before Hon. Commissioner of Patents, I shall make a motion for permission to amend the preliminary statement of Thomas A. Edison, by adding thereto a reference to a certain caveat known as No. 45, and to the instruments therein referred to, and to the original draft of and time of executing such caveat, and will present affidavits showing how the omissions or inaccuracies in the preliminary statement occurred, and the character of the evidence that will be produced to show the truthfulness of the proposed additional statements, of which affidavits you will be furnished with copies.

(Signed) LEMUEL W. SERRELL,
Attorney for T. A. Edison.

Service of a copy of the foregoing notice admitted the 30th day of November, 1880, and it is hereby agreed and stipulated that the testimony of Thomas A. Edison, and of the witnesses in his be-

half, be proceeded with, in order to avoid the delay that would arise, for the said motion to be decided, and furthermore that the motion shall be treated the same as though it had been noted for a hearing immediately after November 29th, when the existence of the said caveat was first brought to Edison's notice, and that the testimony taken shall be treated the same as if it had been taken after the hearing of the aforesaid motion. B. E. J. EILS,

Attorney for H. C. Nicholson.

No. 2.

MENLO PARK, }
State of New Jersey. }

THOMAS A. EDISON, being duly sworn, deposes and says, that he is one of the parties in the interference on Duplex Telegraphs between Henry C. Nicholson and himself. That he has presented to the Patent Office three preliminary statements; the first was sworn to April 27, 1878; the second March 31, 1879, and the third, April 19, 1879. That in preparing these statements he trusted very largely to his memory; that he had a large number of sketches and memoranda, but that very few of them had any dates upon them; that he did not commence to date his sketches, as a regular thing, until some time in 1874. That he had the printed copies of evidence given in 1877, in the suit between the Atlantic and Pacific Telegraph Co. and Western Union Telegraph Co. and others, and that this evidence was generally familiar to him. That he prepared his preliminary statements so far as facts and dates, without the assistance of his counsel, L. W. Serrell.

That on November 27, 1880, said Serrell came to Menlo Park to look over matters with him to prepare for taking evidence in the said interference with Nicholson. That sketches, &c., were gone over, and scarcely any found with dates. That deponent promised to look over his records further. That on Monday, November 29, 1880, said Serrell

was looking over matters with deponent and suggested an examination of copies of caveats. That this was done and a copy of caveat 45 was found which contained the subject matter of this interference.

That deponent had forgotten entirely that there was any caveat showing the devices therein set forth; that he had not referred to the same in making out either of his preliminary statements, and so far as deponent remembers, or can discover, no reference was made to the said caveat in the litigation aforesaid. He is unable to account for either of these facts, except by saying that when he made out his preliminary statements the copies of his caveats were scattered among the mass of notes, memorandums, &c., in his office, which had not at that time been put into order, and he either did not have said caveat at those times (as several copies have been since furnished in completing his set), or else the copy was mislaid. And in regard to the failure to refer to the said caveat, in the litigation aforesaid, he can only explain that said suit related to the *ownership* only of the invention now in controversy, and not to the origin of the invention, and there was a general cross-fire in the proceedings, as the deponent was called for the plaintiff, and his counsel, Mr. Serrell, was one of the defendants and gave his evidence for said defendants.

That upon discovery of the copy of said caveat No. 45 and upon reference to his original draft of the said caveat he found that it was of great importance that he be permitted to amend his preliminary statement, by refering to the original draft of said caveat, the dates that are fixed thereby, and the collateral circumstances of the use of the instrument shown therein. That when he made his preliminary statements he named December, 1873, as the time when the instruments in interference were made and used; that by said caveat he is able to define the fact that the instruments were tested and their operation determined at the time he

wrote out the said caveat; that the discovery of said caveat led him to seek the evidence of four persons that saw the apparatus in actual use, and deponent is informed that they fix the date as the end of September or the beginning of October, 1873, and that evidence has been taken to establish these facts.

That deponent believes that it is a matter of justice that permission be granted to him to amend his preliminary statement, in view of the discovery of the caveat and the evidence of Norman C. Miller, A. S Brown, A. B. Chandler, and U. H. Painter, the importance of whose evidence deponent did not appreciate until he discovered said caveat, because said caveat determined the character of the devices that they saw.

(Sig'd) THOS. A. EDISON. [SEAL.]

STATE OF NEW JERSEY, } ss.:
County of Middlesex, }

Be it remembered that on this 11th day of December, 1880, before me, a notary public duly appointed in and for said county, personally appeared Thos. A. Edison, who I am satisfied is the person described in and who executed the foregoing instrument, and I having first made known to him the contents thereof, he acknowledged that he signed, sealed, and delivered the same as his voluntary act and deed, for the uses and purposes herein expressed.

S. L. GRIFFIN,
[SEAL] Notary Public,
Middlesex Co.

No. 3.

STATE OF NEW YORK:

LEMUEL W. SERRELL, being duly affirmed, says that he is of counsel for Thos. A. Edison in his matter of interference on telegraphs, with Dr. H. C. Nicholson.

That on Friday, November 26, 1880, he was present at the conclusion of the evidence in behalf of

Dr. Nicholson; that on Saturday, November 27, he visited Menlo Park to see if said Edison had gone over his memoranda and various matters of evidence so as to be ready for his examination on Monday, November 29, pursuant to notice for taking the said evidence; that at that time he went over a large mass of drawings and sketches, but unfortunately they were mostly without dates; that he remained with him until after six o'clock for that purpose, and said Edison promised to look over his various records and the evidence he had given in a litigation relative to the ownership of the invention in controversy, and be ready for the examination on Monday; that on Monday when deponent arrived, ready to go on with said evidence, he discovered that said Edison had not been able to do anything in preparation after deponent left Saturday night, that thereupon deponent went over with said Edison his numerous memoranda still further, and among other things discovered a copy of his caveat No. 45, from which it appeared that the caveat was signed and sworn to as early as October 28, 1873. That deponent had not examined the copy of said caveat between the time of its preparation and the said 29th day of November, 1880, so far as deponent recollects, and he did not draw said caveat originally, it having been drawn by said Edison himself, and deponent did not remember that said caveat described any such devices as were found in it until its copy was referred to, and its contents examined.

That at the time of the preliminary statements of the said Edison, in this case being made out, deponent requested said Edison to furnish the particulars for the same; that this was done, and in one instance at least the preliminary statement was sent off by said Edison himself without being seen by deponent; that until Saturday, November 27, 1880, deponent had never gone over the memoranda or evidence of the said Edison with him, so far as dates and experiments

relating to this case, because deponent believed the said Edison to be fully posted in the premises, and he believed that said Edison, in the prior litigation between A. & P. Tel. Co. and W. U. Tel. Co., had become fully impressed with all the facts, and therefore had reason to presume that the preliminary statements would be complete.

That said preliminary statements show that the invention had been conceived and largely reduced to practice, but fail to refer to the caveat in question, or to the instruments, as made at about the time thereof.

Deponent has had the original draft of caveat No. 45 in his possession ever since it was sent to his office by said Edison. That in deponent's note book under date of Monday, Oct. 20, 1873, the following entry is made in deponent's own handwriting:

"Miller caveat duplex Edison, No. 45 (long) 15."

That from this entry deponent knows that said caveat had been prepared from said Edison's original draft by that date. That this caveat was prepared by the order of Norman C. Miller, and charged to him; that said Miller never furnished the funds for said caveat, as the other books of deponent show, and furthermore, deponent finds by his books that said caveat was not sent to the Patent Office until the end of August, 1874, and the same was filed September, 1874, and the expenses thereof were paid, pursuant to bills rendered to Geo. B. Prescott.

That since the notice for the present motion for permission to amend the preliminary statement deponent has proceeded to take evidence, as by consent, and in such evidence the existence of the draft of said caveat, its preparation and execution, have been proved, and the existence of the devices therein referred to demonstrated early in August, 1873, and exhibited to several persons the latter part of September or early in October, 1873; hence the propriety of permission to amend preliminary state-

ment will be apparent, because the amendment will only include matters that hereafter will be evidence in Court; and the omission from the preliminary statements have been entirely accidental and without any intention to mislead.

LEMUEL W. SERRELL.

Affirmed before me this 13th day of December, 1880.
[SEAL] GEO. T. PINCKNEY,
Notary Public.

No. 4.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., Dec. 17, 1880.

IN RE INTERFERENCE.

NICHOLSON
v.
EDISON
DUPLEX TELEGRAPHS.
Before the Examiner of Interferences.

T. A. EDISON,
Care L. W. Serrell,
N. Y. City:

Please find below a communication from the Examiner in charge of Interferences in regard to the above-cited case.

Very respectfully,
E. M. MARBLE,
Commissioner of Patents.

The motion must be denied upon the authority of Hopkins vs. LeRoy, 18 O. G., 859.

Limit of appeal seven days.

No. 5.

IN THE MATTER OF INTERFERENCE.

THOMAS A. EDISON AGAINST H. C. NICHOLSON.

Interlocutory Appeal from Examiner of Interferences relative to permission to amend Preliminary Statement.

NEW YORK, Dec. 21, 1880.

HON. COMR. OF PATENTS:

SIR: On the above-named matter the present is to request an interlocutory appeal to your Honor on the following state of facts.

Permission is asked to amend preliminary statement, on the ground that recently-discovered evidence, the existence of which had been entirely lost sight of and forgotten, rendered an amendment of the preliminary statement important. This is denied on reference to the decision of your Honor in the case Hopkins vs. Leroy (18 O. G., 859).

You are asked to overrule and reverse the action of the Examiner of Interferences, and give permission to file an amendment to the preliminary statement, for the following reasons:

1st. A preliminary statement is necessary and proper as a check to prevent fraud, hence it is only the same as an answer or pleadings in a Court, and cannot be considered any more final and binding; regulations concerning amendments to preliminary statements should be similar to those in Court; where material amendments are permitted after the other party has taken evidence, he should be indemnified for expenses he may have incurred by reason

of the misapprehension of the position of the other party. In this case nothing of that kind can arise, as the expenses of BOTH parties are paid by W. U. Telegraph Co.

2d. A preliminary statement is filed pursuant to a *rule*. No rule is legal, valid or operative that subverts the *statute* or is interpreted in opposition to the same.

3d. The statute requires that the question of *priority of invention shall be determined*, and any rule or interpretation which prevents this question being determined is illegal and can be set aside either by your Honor or an appeal to the Supreme Court of the District of Columbia.

(C. D. 1872, p. 185.)
(C. D. 1873, p. 19.)
(Platts and Walden, O. G., vol. 15, p. 827.)

4th. It is believed that while the rule laid down in the case of Hopkins vs. Leroy is generally correct, it should be interpreted so that if one party discovers evidence that he had forgotten or did not know of, and in good faith gives notice promptly of the same and of motion to amend his preliminary statement, he should be permitted to do so, because—

(*a*) Human nature is not perfect, and a man's memory is liable to be in error.

(*b*) Because the reliability of the evidence sought to be introduced can be fully inquired into, and rejected if insufficient.

(*c*) Evidence should not be excluded from the Patent Office that could afterwards be properly introduced in Court, because the decision of the question of priority of invention is based on the the same principles in both cases.

5. While it is proper to prevent fraud and deception, and rules should be inforced to prevent one party gaining an undue advantage of another,

neither law nor decisions favor the suppression of facts by technicalities.

6. In this particular instance, *documentary evidence*, of the most convincing character, is offered, and to prevent its admission on the technical ground that the preliminary statement is silent in regard to it, is to close up the most reliable channels of evidence, and to make the Patent Office a party to the perpetration of a wrong under the guise of regulations.

7. All rules are to be interpreted for the furtherance of justice, and for the carrying out of what is legal; and they are to be interpreted somewhat according to circumstances. In this case, the lapse of time from 1873 to the time the first preliminary statement was made, a period of five years, is to be taken as an extenuating circumstance.

8. Rule 110 makes express provision for amending the preliminary statements. Motion to amend the present preliminary statement was made *the very day the error was discovered*. It could not be made before the taking of evidence, because the error had not been discovered. The affidavits submitted show that the correction is essential to the ends of justice. It is believed that under this rule the permission to amend should be allowed, because all the terms of said rule have been complied with.

Yours respectfully,

L. W. Serrell,
Attorney for Edison.

Mailed Dec. 21, 1880.

No 6.

Department of the Interior,
United States Patent Office.
Washington, D. C., January 20, 1881.

L. W. Serrell, Esq., New York, N. Y.:

Sir—In answer to your telegram of the 15th inst., you are informed that the decision of the Commissioner of Patents on Edison's motion to amend preliminary statement was merely an affirmation of the decision of the Examiner.

Very respectfully,
M. Seaton,
Chief Clerk.

No. 7.

To the Hon. Secretary of the Interior:

The petition of Thomas A. Edison of Menlo Park, in the State of New Jersey, respectfully showeth:

That he made application Sept. 1, 1874, for Letters Patent on Duplex Telegraph, known as case 99. That after numerous proceedings therewith connected, his said application was put into interference with the applications of Henry C. Nicholson, filed Oct. 14, 1874 and May 11, 1876.

That he filed preliminary statements in such interferences, and that he gave notice for taking evidence, and that in preparing for such evidence he discovered a certain caveat filed by him and the original draft thereof, whereby the time of the conception of the device in controversy was more clearly established and by which he was also enabled to more positively ascertain the time when the invention was put into practical operation. That it appeared to be proper to amend his preliminary statement, and thereupon he gave notice according to rule 149 of a motion to amend his preliminary statement as authorized by rule 110. That said rule expressly provides that in case of material error such statement may be corrected.

That upon the hearing of the said motion, permission to amend was denied without the assignment of any special reasons in this case, all of which appear in files of the case.

That in this your petitioner believes that the Hon. Commissioner of Patents acted contrary to the rules of the Department, and contrary to law, for the following reasons:

1st. There is no exception taken by the opposing

party to any of the formalities in the case, neither is there by the Commissioner.

2d. The evidence sought to be introduced in the case is legal evidence that would be received in the U. S. Court, as will be found on reference to the files in the case.

3d. Unless the motion to amend the preliminary statement is granted, opportunity will be given to opponents to object to the reception of portions of the evidence on the ground that it is not permissible under preliminary statement, and thereby there will be a risk of the exclusion of legal evidence at the hearing of interference, and hence priority of invention may be illegally awarded to the party who is not the first inventor.

4th. That any rule of the Patent Office that operates directly to exclude legal evidence from an interference is illegal and must be so modified or interpreted that legal evidence cannot be excluded from an interference on a mere technicality.

5th. That the motion to amend is amply supported by affidavits that have not been objected to or questioned, either as to reliability or sufficiency, and said motion has been made in strict conformity to the rules, which provide that the "motion to correct the statement must be made, *if possible*, before the taking of any testimony, and as soon as practicable after the discovery of the error." The affidavits show, and it is not questioned, that the notice of motion to amend was made as soon as possible, and within a few hours after the discovery of the error, and no reason is given why Edison is not entitled to the privilege of amendation, as neither fraud or deception, or any intentional error is even charged against him.

6th. That the Hon. Commissioner of Patents has substantially changed the rules of the Patent Office without notice or authority. His decision substantially says, that "motion to correct the statement must be made before the taking of any evidence," leaving out the proviso "*if possible*." Such action on his part should therefore be set aside.

Your petitioner therefore requests that your Honor will set a time for the hearing of this petition, and upon a hearing of the case grant an order allowing Edison to amend his preliminary statement, and thereby over-rule the action of the Hon. Commissioner of Patents.

THOMAS A EDISON,
per LEMUEL W. SERRELL,
Att'y.

New York City, March 8, 1881.

No. 8.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., March 29, 1881.

HON. S. J. KIRKWOOD,
Secretary of the Interior:

SIR: I have the honor to acknowledge the receipt by reference of a communication addressed to you, signed Thomas A. Edison, by Lemuel W. Serrell, Attorney, representing that my action in refusing to allow an amendment of the preliminary statement of said Edison, in a case entitled Thomas A. Edison vs. Henry C. Nicholson, is contrary to the rules of the Department, and contrary to law for the following reasons:

"1st. There is no exception taken by the opposing party to any of the formalities in the case, neither is there by the Commissioner.

"2nd. The evidence sought to be introduced in the case is legal evidence that would be received in the U. S. Court, as will be found on reference to the files in the case.

"3rd. Unless the motion to amend the preliminary statement is granted, opportunity will be given to opponents to object to the reception of portions of the evidence on the ground that it is not permissible under preliminary statement, and thereby there will be a risk of the exclusion of

"legal evidence at the hearing of the interference, "and hence priority of invention may be illegally "awarded to the party who is not the first inventor.

"4th. That any rule of the Patent Office that op-"erates directly to exclude legal evidence from an "interference is illegal and must be so modified or "interpreted that legal evidence cannot be excluded "from an inteference on a mere technicality.

"5th. That the motion to amend is amply sup-"ported by affidavits that have not been objected "to or questioned either as to reliability or suf-"ficiency, and said motion has been made in strict "conformity to the rules which provide that the "motion to correct the statement must be made, if "possible, before the taking of any testimony, "and as soon as practicable after the discovery of "the error. The affidavits show, and it is not "questioned, that the notice of motion to amend "was made as soon as possible, and within a few "hours after the discovery of the error, and no "reason is given why Edison is not entitled to the "privilege of amendation, as neither fraud or de-"ception or any intentional error is even charged "against him.

"6th. That the Hon. Commissioner of Patents "has substantially changed the rules of the Patent "Office without notice or authority. His decision "substantially says that 'motion to correct the "statement must be made before the taking of any "evidence,' leaving out the proviso, 'if possible.' "such action on his part should, therefore, be set "aside."

On January 13, 1881, I heard and decided the motion of Mr. Edison above referred to, brought before me on appeal, from the Examiner of Interferences, by whom it had been denied in accordance with the ruling in the case of Hopkins vs. LeRoy, 18 O. G., 859. The action of the Examiner was affirmed by me for the same reasons. In the case above cited it was held: "If anything is to be "gained by requiring a party to file a preliminary

"statement, it can only be on the hypothesis that "such statement is to remain intact, and that the "party making the same shall be bound by the "matters therein set forth. Whether such state-"ment be considered as a pleading or not it seems "to me is not very material. When a party makes "and files his preliminary statement, it is to be "presumed that he has fully canvassed all the facts "in his case, and that the statement, as filed, as "far as is necessary, is a correct statement of such "facts. Unless the party having made such state-"ment asks to amend the same before any testi-"mony is taken in the case, all parties *have a right* "to proceed on the issue as made in the respective "statements. It may be that a statement "made contains an erroneous date, as is "claimed in this case; if so, the party making "the statement should correct that date before "his opponent has been put to the expense of tak-"ing testimony to sustain his own case. A party "has no right to wait until his opponent has fully "developed all the facts in his case and then, for "the first time, make known the error that he has "committed in his preliminary statement. Proper "diligence on his part would have placed him in "possession of the facts upon which he could have "corrected his statement before such testimony was "taken. If through carelessness or negligence he "has failed to have such correction made, other "parties should not be injured by such negligence.

"The application in this case to amend comes too "late. If amendment can now be made for the "reason stated, it should be and could be made at "any stage of the proceedings in the case, and if "amendments in preliminary statements are al-"lowed in any stage of the proceedings therein, the "whole object of requiring preliminary statements "would be defeated."

The motion to amend the preliminary statement was made, it is claimed, under the provision of rule

110 of the Rules of Practice of this Office, which reads as follows:

"In case of material error in the statement, "arising through inadvertence or mistake, it may "be corrected on motion (see Rule 149) upon showing to the satisfaction of the Commissioner that "its correction is essential to the ends of justice. "The motion to correct the statement must be "made, if possible, before the taking of any testimony, and as soon as practicable after the discovery of the error."

Rule 105 provides "Each party to the interference "will be required to file a concise statement, under "oath, showing the date of his original conception "of the invention, of its illustration by drawing or "model, of its disclosure to others, of its completion, and of the extent of its use. The parties "will be strictly held in their proof to the dates set "up in their statements. The statement must be "sealed up before filing (to be opened only by the "Examiner of Interferences), and the name of the "party filing it, the title of the case, and the subject of the invention indicated on the envelope."

It will be observed that the essentials of a preliminary statement are, that it shall show (*a*) the date of the original conception of the invention; (*b*) its illustration by drawing or model; (*c*) its disclosure to others; (*d*) its completion; and (*e*) the extent of its use.

An interference was declared in this case on March 7, 1879; Mr. Edison's first preliminary statement was sworn to March 31, 1879, and an additional statement April 19th, following. The testimony in this case was not commenced until September, 1880. More than a year, therefore, had elapsed, after filing his preliminary statement as amended, before any testimony was taken. The attention of Mr. Edison, as well as that of his attorney, must to some extent have been given to the preliminary statement filed; and I cannot conceive, if proper attention and diligence had been given to it, either by Mr. Edison or by his attorney, that it

was impossible for any and every correction necessary to have been made before the taking of any testimony. The fact that such attention was not given to the preparation of the case, it seems to me, is quite clearly shown by the affidavit of Mr. Serrell, filed with this motion.

Negligence ought not to be rewarded by this office nor regarded with special favor by any one. Some rule must be adopted by the office, which will be enforced without regard to parties. If a preliminary statement is to have any force and effect in determining the testimony which parties may introduce, the rule laid down in the case of Hopkins vs. Le Roy seemed to me then, and still appears to me to be, the correct one. This office has not the powers of a Court, nor can it execute and enforce its orders so as to secure in all respects the rights of parties, as may be done in Court. Amendments to pleadings may be made in Court upon such terms as the Court may deem proper. The condition of cases, however, and the situation of parties are quite unlike those in interference cases. In interference cases the parties usually live long distances from each other, and the taking of testimony is attended with great expense. The only guide which a party can have, and the only basis upon which he can determine whether he should take testimony and proceed to trial for the purpose of securing what he deems to be a valuable right, is the preliminary statement or statements of his opposing party or parties. Upon consideration of those statements and the facts disclosed in his own, he decides whether he will incur any expense in contesting the right to the invention claimed. If, after having taken his entire testimony and disclosed his case, his opponent can then amend his preliminary statement so as to antedate the invention as proven by him, it seems to me that it is useless that any preliminary statement should be required.

There are cases, undoubtedly, where the preliminary statement should be amended, even after

the taking of testimony. If it should be shown that the papers containing the dates, illustrations, &c., of a party's invention were in the possession of another, and that he was unable to secure them in time to make his preliminary statement, and hence that he was compelled to make the same from memory; if he subsequently come into possession of said papers, and it is then found that the dates are wrong, undoubtedly he should be allowed to amend, although the testimony of his opponent had been taken. Other cases there may be, as where an administrator files a preliminary statement without having the data upon which to correctly state the dates, &c., or where a guardian or next friend files such statement without all of the facts before him, that amendment should be allowed; but I cannot conceive it proper to allow such amendment where parties have or may have all the papers and data in the case at hand, are able to employ and do employ skillful attorneys to attend to their business, and neither themselves nor by their attorneys properly attend to the business in time.

I cannot conceive, as before stated, that there was any impossibility in so preparing the preliminary statement in this case, that there was any necessity for amending it. It is true in this case, as in every case, that the patent should issue to the right party; but it is also true that in the administration of the law, and the attempt to secure the rights of all persons, rules must be adopted and they must be enforced. Where proper cases are presented for the liberal administration of such rules, undoubtedly they should receive a liberal construction; but such liberal construction should only be given when good and sufficient grounds are shown, not the mere negligence of parties.

The papers in this case are herewith transmitted.

Very respectfully,

Your Ob't Serv't,

E. M. MARBLE,

Com. of Patents.

Ex'd, C. F.
L. M.

1

UNITED STATES PATENT OFFICE.

SAWER and MAN
vs.
EDISON.
} Electric Lights. 2

To AMOS BROADNAX, Attorney for Sawyer and Man:

Please take notice, that on Friday, June 10, 1881, at eleven o'clock A. M., at No. 65, Fifth Avenue, New York City, I will proceed to take the testimony of T. A. Edison, Charles Batchelor, E. H. Johnson, John Kruesi, and others, in behalf of said Edison, and continue the examination from day to day until completed. 3

You are invited to be present and cross-examine.

DYER & WILBER,
for Edison.

Washington, D. C. Good service this eighth day of June, 1881.

AMOS BROADNAX,
Atty for Sawyer and Man.

4

UNITED STATES PATENT OFFICE.

SAWYER and MAN
vs.
THOMAS A. EDISON.
} Electric Lights.

Pursuant to notice hereto annexed, Mr. Z. F. Wilber appeared for Mr. Thomas A. Edison, at 11 o'clock

5 A. M., this 10th day of June, 1881, at No. 65 Fifth Avenue, New York City; and at the request by telegram of the attorney for Sawyer & Man, I have postponed the taking of testimony until 11 o'clock A. M., June 11th, at same place.

WM. H. MEADOWCROFT,
Notary Public and Commissioner,
New York County.

NEW YORK, June 11th, 1881.

6 Pursuant to adjournment the counsel for the respective parties appeared before me at No. 65, Fifth Avenue, New York City, at 11 o'clock, A. M., George W. Dyer appearing as counsel for Thomas A. Edison, and Amos Broadnax as counsel for Sawyer & Man.

By consent, the questions and answers were reduced to writing by H. W. Seely, he having first been duly sworn to faithfully and truly record the same.

7 THOMAS A. EDISON, a witness produced in his own behalf, being duly sworn, testified as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison:

1 Q. Please state your age, and residence and occupation?

A. Age, 34; occupation, inventor; residence, Menlo Park, N. J.; for the time being living in New York City.

8 2 Q. Please relate in detail your earliest experiments in the carbonization of paper?

> Question objected to, unless the experiments were made, or to be used, or with a view of using the paper in electric lighting, and unless the intention was to make the paper in burners for electric lamps.

A. I carbonized paper in the summer of 1876. Such paper was to be used for battery carbons, for non-conductors of heat, and articles were to be

[NOT FILMED: PAGES 3-93 (EDISON'S TESTIMONY; EDISON'S EXHIBIT NO. 3). SEE EDISON ELECTRIC LIGHT CO. v. UNITED STATES ELECTRIC LIGHTING CO., VOL. 5.]

873 5, 3,47,
6, 20.26,
7, 12.15,
8, 22.00,
9, 9.00, total time burned, 160 hrs up to 5 P.M.
9, 6.50,
10, 19.15,
11, 7.00,
12, 11.00, " " " 204.15 up to noon.
12, 11.30,
874 13, 22.30,
14, 11.30, " " " 259.45 " "

875

876

Edison's Exhibit No. 7. 877

Extract from records of experiments, book No. 85:

"All pumps give a great deal of trouble at F where a contraction is made so that the air in G may be forced out from H.

B. This stop cock placed too far from the main reservoir so that the tube near it caught air. This could be worked out by letting the Hg work up and down. The MacLleod should not be used until a high vacuum has been attained. For if this has 878
not been done the Hg sticks in the side tube. Last evening a vacuum was obtained so that the spark jumped five inches outside of the tube rather than across ¼ inch in vacuum. The changes in vacuum were extremely rapid from green to preventing a small spark in a few seconds and then in a few minutes to stopping the large spark. The finely divided copper and sulphuric acid may have had a strong influence on this F, the tube contracted here
so that a pressure can be obtained in G to drive the 879
air out through the stop cock H.

The enlargement of the tubes at L and L¹ is a mistake, as a bubble of air collects here and is drawn up into the pump. Making stop cock D with tube to left inclined upwards may be a mistake, as the Hg collects above the cock and stops the Geissler. Pure black rubbber tube placed inside of white rubber to prevent soiling Hg.

Edison Exhibit, No. 8. 880

[*New York Sun, December 22d, 1879.*]

ELECTRICIAN SAWYER'S CHALLENGE TO ELECTRICIAN EDISON.

If a party possesses an interest in something that he considers valuable, he is not very likely to part with it, especially if it be something in the line of electric lighting, where what may nominally be $1 may really be $1,000. Therefore, when Mr. Edi-

381 son sells out all his interest in his electric light there is a reasonable chance for a suspicion that he considers his invention worth very little.

Mr. Edison's reputation before the public is founded upon the newspaper publications about: 1. The quadruplex telegraph; 2. The telephone; and 3. The phonograph.

As to the quadruple telegraph, I may say that it was an adaptation of the French and German systems. When Mr. Edison took hold of the 4-plex
382 there were already known five systems of 2-plex, three of 4-plex, and three of 6-plex and 8-plex.

The 4-plex of Edison was a failure. A modest young gentleman, Assistant Electrician of the Western Union Telegraph Company, whom I have not seen for several years (Mr. Gerritt Smith), made it a success, and some day he will get the credit for this invention; for he, and not Edison, is the genius in this case.

As to the telephone, Mr. Edison is not the in-
383 ventor. Andrew Graham Bell is the inventor of the telephone.

As to the phonograph, which really made Mr. Edison's reputation, it is of no earthly value, and the manufacture by Bergman has practically been dropped. The real inventor of the phonograph will never be known, in all probability, for I understand that Mr. Edison anticipates a Western man but three days in priority of invention.

Now, all that remains for Mr. Edison is electric
384 light. He is going over the same ground that Bouliguine, Lodygreine, Kosloff, Koun, Starr King, myself, and others have traversed—first, iron; second, platinum; third, carbon in different shapes. And Edison has failed, in my opinion. To show that I mean what I say, I deny every one of his allegations made at the Saratoga Convention of the American Society for the advancement of Science, and, specifically, I challenge him:

First. To maintain a vacuum in his lamps.

Second. To run his carbonized paper lamp three

hours. (In practice, in a perfect vacuum, it will last twenty minutes.) 385

Third. To consolidate platinum by heating electrically in the Sprengel vacuum, as he claims.

Fourth. To prove that his dynamo-electric machine develops not ninety, but even forty-five per cent. of the feet pounds applied to it.

Fifth. To show that he can obtain a light of twenty-five candles from platinum with less than three-horse power.

Sixth. To show that platinum or iridium will 386
not disintegrate in twenty hours' actual running.

Seventh. To prove that with his carbonized-paper lamp he can obtain two lights of ten candles each per horse power.

Eighth. To show that the effect of the oxide of magnesium is to harden his wire, and make it more refractory.

And I further allege that all Mr. Edison's statements are erroneous, and I offer $100 as a prize for him to prove each of the above eight allegations. 387
Let him run one of his lamps three hours, and the public will be satisfied that I am correct.

W. E. Sawyer.

78 Walker street, New York, Dec. 21.

388

389 Pursuant to adjournment this testimony was continued June 27th, 1881, at 10 A. M., at No. 65 Fifth Avenue, New York City, same counsel being present.

MARTIN N. FORCE, a witness produced in behalf of Mr. Edison, being duly sworn, testified as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison.

1 Q. What is your residence and occupation; by
390 whom are you employed, and how long have you been so employed?

A. My residence is Menlo Park, N. J. My occupation is assisting Mr. Edison in his experiments. I have been so employed since about 1875.

2 Q. What sort of work did you first do for Mr. Edison:

A. I did carpenter work.

3 Q. If you did any particular carpenter work for him in relation to the laboratory, please state what it
391 was and when it was done?

A. I helped to erect the laboratory, putting up shelves in the same, and I did carpenter work at his pen factory; about in the fall of '75 and the spring of '76.

4 Q. If at any time you changed the nature of your work for Mr. Edison, what new work did you enter upon, and when did you do so?

A. I was at the pen factory packing the pens, and some of the time I ran the engine. Then I went in
392 the laboratory to assist in the laboratory, about the spring of '78. My duties were anything I was asked to do; assisting at making and charging batteries, cleaning the laboratory and such work. And since that time my work has been general in the laboratory, assisting wherever I was called upon.

5 Q. Please examine the paper now shown you, marked Edison's Exhibit No. 5. State whether the signature M. N. Force upon the same is your signature, and when was the same made?

Question objected to as going to show that

the invention in question was made before the date alleged in the preliminary statement of Mr. Edison. 393

A. I have examined the paper: the signature is mine. It was made at the date of this paper, December 3d, 1877.

6 Q. Please look at Exhibit marked Edison's First Incandescent Lamp, and state whether you have seen the same before, and if so when and where?

Same objection as to previous question.

A. I have looked at the instrument. I have seen 394
it in the laboratory at Menlo Park. I have seen the instrument setting on the shelf at the upper part of the laboratory. I should say it was about three years ago, as near as I can remember.

7 Q. Have you assisted at any experiments in electric lighting with incandescent paper carbons or witnessed such experiments at Menlo Park; if so state the earliest times of the same?

A. I assisted Mr. Batchelor about September or October, 1878, I don't exactly know which, to make 395
some carbons. The carbons were rolled with a sort of a coating of tar, and carbonized in a crucible filled with charcoal or something of that description, and also carbonized in a combustion tube. As near as I can remember at that time they were put in the bell jar of a vacuum pump. The air was then exhausted, and an electric current passed through the carbon.

7 Q. Please examine the paper now shown you marked Edison Exhibit No. 9. State whether or 296
not the sketches on that paper represent the bell-jar employed in the experiments you have related.

A. I have examined the Exhibit No. 9. and find it to be as near as I can remember a drawing of the vacuum pump which we used at that time.

Counsel for Edison gives notice that he here closes his examination-in-chief of this witness, and gives him over for cross-examination.

397 CROSS-EXAMINATION BY AMOS BROADNAX, ESQ., COUNSEL FOR SAWYER AND MAN:

Counsel for Sawyer and Man gives notice that his cross-examination is not intended to waive any objection taken to the testimony.

8 x-Q. Did you sign your name on this paper, Edison Exhibit, No. 5, in presence of Mr. Edison and Mr. Batchelor?

A. Yes, sir.

398 9 x-Q. Where were they?

A. In the laboratory, at Menlo Park.

10 x-Q. Was it in the morning or in the evening?

A. In the evening.

11 x-Q. Was it by gaslight or by daylight?

A. I don't exactly remember whether it was by gaslight or by daylight.

12 x-Q. What was the object of making that paper?

A. As a record, I suppose, of the experiment.

399 13 x-Q. What experiment?

A. The experiment shown on the paper.

14 x-Q. In whose handwriting is this paper?

A. It looks like Mr. Edison's handwriting somewhat.

15 x-Q. Did you see him write it?

A. I do not remember seeing him write it.

16 x-Q Can you swear that that is his handwriting?

A. No, sir, I wouldn't swear that it's his hand-
400 writing.

17 x-Q. Can you swear that that paper was written December 3d, 1877?

A. No, sir, I wouldn't swear that it was written at that date, of course.

18 x-Q. Can you swear that you signed your name on it on December 3d, 1877?

A. I can swear that that's my signature.

19 x-Q. Can you swear that you made this signature on December 3d, 1877?

A. I made that signature at that time; yes, sir.

20 x-Q. How do you fix the date of the making 401
of that signature on that paper?

A. I have no particular way of fixing the date, but generally at the time an experiment is tried we always sign, and I never sign unless I see the experiment.

21 x-Q. Did you witness the experiment referred to on that paper?

A. Yes, sir, I was there at the time, but I don't know the details of the experiment.

22 x-Q. What was intended to be proved by the 402
experiment?

A. I couldn't say what he intended to prove.

23 x-Q. What did the experiment consist of. What did he do?

A. I don't remember. I can't give the details of the experiment.

24 x-Q. How do you know that the experiment referred to on that paper was made on or about December 3d, 1877. What circumstance can you
mention that was contemporaneous with that ex- 403
periment?

A. I don't know that I have anything particular to call the same to my mind. I used to frequent the laboratory to see them experiment, but did not enter into the details of the experiments. There is no particular circumstance that I recall to my mind.

25 x-Q. Did you see Mr. Edison make any experiments with the Exhibit Edison's First Incandescent Lamp?

A. No, sir; I don't remember seeing any. 404

26 x-Q. You say you assisted Mr. Batchelor to make some carbons out of paper coated with tar. Did you mean to be understood as saying that the carbon you assisted Mr. Batchelor to make was in the form of a knitting-needle?

A. The carbons that I assisted Mr. Batchelor to make were rolled by the hand, coated with tar, and in the form of a small cylinder.

27 x-Q. How big were they?

A. They were different sizes. They may have

405 been the size of a quill, or the size of a finger, or smaller.

28 x Q. How much smaller were they. Were any of them as small as an eighth of an inch in diameter?

A. I don't just remember the sizes, and couldn't say as to that. We didn't care particularly as to the size.

29 x-Q. Can you state how long they were?

A. They may have been an inch, or two inches,
406 or three inches.

30 x-Q. How many of them did you make?

A. I would not say as to the number. There may have been ten, or there may have been fifty.

31 x-Q Did you see any of these carbons put in the vacuum chamber of the pump represented by Edison Exhibit No. 9?

A. Yes, sir; I think I saw those put in.

32 x-Q. Are you sure you saw those carbons put
407 in that chamber?

A. Yes, sir; in a chamber similar to this drawing.

33 x-Q. How many did you see put in?

A. I don't just remember the number: I think there were more than one?

33 x-Q. Can you swear that there was more than two put in?

A. I wouldn't swear that there were more than two; there may have been. My memory don't serve me as to that point.

408 34 x-Q. Was you present during the whole of the experiment?

A. I was present with Mr. Batchelor at the carbonizing and at the vacuum pump. I wouldn't say that I was always at that place, but I was usually present.

35 x-Q. Did you work the vacuum pump?

A. Yes, sir; I used to do the pumping most of the time.

36 x-Q. Did you see these carbons illuminated by the electric current in the vacuum chamber of the pump?

A. Yes, sir; I remember of seeing them lighted. 409

37 x-Q. Did you see more than one of them lighted?

A. I don't say as to the number I have seen lit, but I remember seeing the carbons illuminated in that chamber.

38 x-Q. Was there more than one pump in the vacuum chamber of which you saw these carbons placed and illuminated?

A. No, sir; there was only the one pump at that time.

39 x-Q. Was there more than one carbon in the 410
chamber at any one time?

A. I don't remember more than one at a time, but there may have been more.

40 x-Q. Did the experiments last more than one day?

A. I would not say as to that. I don't remember how many days.

41 x-Q. Who was present during these experiments besides yourself and Mr. Batchelor?

A. I think Mr. Edison was present. I don't call 411
to mind any others.

42 x-Q. Were the experiments continued more than two days?

A. I don't remember how many days. It may have been one or two, or perhaps a week.

43 x-Q. Can you swear that these experiments continued for more than two days in the fall of 1878?

A. I would not swear that they were continued
more than two days, although they may have been? 412

44 x-Q. Can you swear that they were continued for two days?

A. I think, as near as I can remember, they were continued for that length of time.

45 x-Q. When the carbons were illuminated by the electric current, how long did they last?

A. I would not say as to how long they lasted exactly.

46 x-Q. Well, about how long?

A. As near as I can remember, they lasted prob-

413 ably a minute, or a couple of minutes, or five
minutes.

47 x-Q. These paper carbons about which you have been testifying, are they the first which you saw made at Menlo Park by Mr. Edison and Mr. Batchelor?

A. As near as I can remember, they were about the first.

48 x-Q. And you are certain that that was in the fall of 1878?

414 A. Yes, sir; it was in September or October, 1878,
to the best of my recollection.

MARTIN N. FORCE.

EDWARD H. JOHNSON, a witness produced in behalf of Mr. Edison, being duly sworn, testified as follows in answer to questions proposed by George W. Dyer, counsel for Edison:

415 1 Q. State your residence and occupation, and
whether or not you are one of the assistants of Mr.
Edison, and if so, how long you have been with him
in that capacity?

A. I reside in New York City. My occupation is
that of a practical electrical engineer. I have been
engaged for the past ten years in practically apply-
ing Mr. Edison's inventions in telegraphy, tele-
phony, and now in the electric light, and in such
capacity I have been his assistant, not directly em-
416 ployed in his laboratory until September last, but
always with the parties who were putting Mr. Edi-
son's inventions on the market. My relations with
him and his work were such that I was a very fre-
quent visitor at his laboratory.

2 Q. What, if anything, do you know of the experiments of Mr. Edison in the summer of 1876, in the carbonization of paper for various purposes.

Question objected to in so far as it applies to electric lighting, if it is intended to show that Mr. Edison carbonized paper for that purpose in 1876?

A. In the fall or winter of 1876 I sought to organ- 417
ize a small business for myself under the name of
The American Novelty Company, the object of
which was to acquire numerous inventions of Mr.
Edison, Mr. Batchelor, Mr. Adams, my own, and
others, and to put them upon the market. Several
such were acquired, namely, Edison's duplicating
ink, Edison's battery carbons, Edison's jeweller's
engraving machines and others which I cannot now
recall. The attempt to form a company to carry on
such a business was practically a failure, owing to 418
the lack of funds. I remember, in discussing with
Mr. Edison at his laboratory, quite prominent men-
tion was made of numerous articles which he, Mr.
Edison, was intending to manufacture of carbon. I
cannot now recall all of them in detail, but they
were such articles as dishes, small vessels, resist-
ance coils, battery carbons, etc. I remember, on
frequent occasions, seeing Mr. Edison carbonizing
certain of these articles under pressure, that being
the particular feature of the invention. In discus- 419
sing the matter with Mr. Edison, Mr. Batchelor and
Mr. Adams, they informed me that they purposed
making such carbons of bituminous coal, paper and
wood. My knowledge of the experiments was
necessarily confined to information given me at the
time by these gentlemen, as I was so occupied in
New York that my visits to the laboratory were
mainly for the purpose and with the object of con-
sulting with Mr. Edison, and not in assisting him
in his experimental work. 420

3 Q. At what date do you know, of your own knowledge, of Mr. Edison engaging in experiments in the electric lights, with incandescent conductors made of paper carbon?

A. I fail to recall now the exact date when I first saw Mr. Edison's paper carbon experiments.

4 Q. When was your first knowledge of Mr. Edison's experiments in electric lights?

A. In the summer of 1878, on his return from the Colorado scientific expedition, which he had accom-

421 panied for the purpose of endeavoring to measure the heat of the corona during the sun's eclipse, with the tasimeter, which he had invented. It is from this date that my recollection runs freely as to Mr. Edison's electric light work. Prior to that, anything that he did did not sufficiently attract my attention to fix either the date or the experiment on my mind.

5 Q. Since the summer of 1878, what has been your knowledge with regard to persistent and con-
422 tinuous work on the part of Mr. Edison in incandescent electrical lights?

A. That Mr. Edison pursued experimentation in this direction uninterruptedly night and day, from that date to this, with his customary energy and persistence, when fully started in a given direction for a given object.

6 Q. What is the earliest date within your recollection of the employment of paper carbon conductors for incandescent electric lights by Mr. Edison?
423 A. I have a not well defined recollection of witnessing certain experiments with paper carbons for this purpose in the winter of 1878–79. In the summer of '79 I went to Europe, and saw nothing more of Mr. Edison's experiments until January, 1880, when I visited Mr. Edison's laboratory upon a mission from England, and there saw a large number of paper carbon lamps in actual operation. I returned to England within a fortnight, taking six of the
424 paper carbon lamps with me, and did not again visit the laboratory until September 1st, 1880.

Counsel for Edison closes the examination-in-chief of this witness and offers him for cross-examination.

CROSS-EXAMINATION BY AMOS BROADNAX, COUNSEL FOR SAWYER AND MAN:

7 x-Q. Please state your name and age, Mr. Johnson.

A. My name is Edward H. Johnson, and my age is 35 years.

8 x-Q. Please to fix the date exactly when Mr. Edison returned from the scientific expedition organized to observe the sun's eclipse? 425

A. I can't fix that date from memory.

9 x-Q. Have you any memoranda to which you can refer, by which you can fix the date?

A. Not to my knowledge. I do not make it a rule to preserve memoranda or papers of any description.

10 x-Q. You say, in answer to question 4 of your examination-in-chief, that the first knowledge you had of Mr. Edison's experiments in electric lights 426
was in the summer of 1878, after his return from the scientific expedition to which I have referred. Please to state whether you derived that knowledge from others or whether you witnessed those experiments yourself?

A. I witnessed numerous experiments myself.

11 x-Q. These experiments that you say you witnessed yourself, were they made immediately upon his return from the scientific expedition referred to? 427

A. I cannot now recollect whether they were or were not.

12 x-Q. State how long after his return you witnessed these experiments, as nearly as you can recollect?

A. I am unable to do that, being wholly without other guide to my recollection than my memory that it was immediately upon his return that he began active experimentation on the electric light.

13 x-Q. These experiments that you say you witnessed, is your recollection of them sufficiently distinct to enable you to describe them? If so, please do so. 428

A. No, sir; it is not. I only remember the fact of frequently seeing Mr. Edison and his assistants occupied with them. My interest was not enlisted, and I did not particularly examine into or investigate this branch of the laboratory work.

14 x-Q. In answer to question 6 of your examina-

429 tion-in-chief you say you have "a not well defined
recollection of witnessing certain experiments with
paper carbons for this purpose in the winter of 1878–
79." Please to state whether your recollection of
the experiments referred to by you in that answer
is distinct enough to enable you to describe them,
and if so, please describe them?

A. My recollection is of seeing a feeble light, and
of Mr. Edison remarking that here might grow out
something from the American Novelty Company
430 experiments. I cannot say what his exact words
were, but this is the purport of them; nor can I de-
scribe otherwise the light that was shown.

15 x-Q. How often did you witness experiments
made by Mr. Edison in incandescent electric light-
ing with carbonized paper in the winter of 1878–79?

A. I cannot say positively that such experiments
as I saw were upon the incandescent principle at
all, my recollection of these experiments being too
indefinite to enable me to describe either the princi-
431 ple or the method of its application.

16 x-Q. State, if you please, when you first saw
this exhibit, Edison's First Incandescent Lamp?

A. It is impossible for me to state when I first
saw it. Mr. Edison showed me his light on more
than one occasion in its earlier stages. I have no
recollection of the shape or design of the lamp re-
ferred to in your question.

17 x-Q. State, if you know, when it was that Mr.
Edison invented and made the tasimeter to which
432 you have referred, for measuring the heat of the
corona of the sun during the expedition to Colo-
rado?

A. I cannot fix the date other than that it
was during the time of his telephone experimenta-
tion, the tasimeter being an invention coincident
with the telephone. It was some time during the
latter half of the year '77 or early part of the year
'78. This is my best recollection.

EDW'D H. JOHNSON.

JOHN KRUESI, a witness produced in behalf of Mr. 433
Edison, being duly sworn testified as follows, in an-
swer to questions proposed to him by George W.
Dyer, counsel for Edison:

1 Q. State your age, residence and occupation.

A. Age, 38; residence, Menlo Park, N. J.; I am a
machinist, at present engaged in the Electric Tube
Works at 65 Washington street, New York, as man-
ager.

2 Q. State how long you have been connected with
Mr. Edison, and in what capacity? 434

A. For nearly nine years. About five years as
machinist and four years as foreman of the machine
shop.

3 Q. Please look at the paper which I now hand
you, marked Edison's Exhibit No. 4, and state
whether the signature J. Kruesi, upon the same, is
your own handwriting and when it was made?

Question objected to as immaterial.

A. I have examined the paper. The signature is
my own handwriting. I think it was made about 435
the time the paper is dated. That is November,
1877.

3 Q. Have you any doubt upon that point?

A. I have no reason to be doubtful about it, but
I don't remember when I signed it.

4 Q. What was your habit or practice about sign-
ing similar papers?

Objected to as not competent. The ques-
tion is as to when he signed this paper.

A. I generally signed them within a few days af- 436
ter they were written, or after the instrument was
made.

5 Q. What is the earliest date which you remem-
ber, of Mr. Edison experimenting with electric
lights?

A. I am not sure whether it was the summer of
'77 or summer of '78.

6 Q. What is the earliest date you remember of
his experimenting with paper carbons for electric
lights?

437 A. I don't remember the date when he began. When he experimented with paper carbon was in 1877, but I don't know what the paper carbons were for.

Counsel for Edison here closes his examination-in-chief of this witness, and submits him to counsel for Sawyer & Man for cross-examination.

438 CROSS-EXAMINATION BY AMOS BROADNAX, COUNSEL FOR SAWYER AND MAN.

7 x-Q. What experiments did you see Mr. Edison make with paper carbons in 1877?

A. I don't remember any experiments.

8 x-Q. Was you foreman of Mr. Edison's machine shop and his laboratory, and generally of his mechanical works at Menlo Park?

A. Yes, sir.

9 x-Q. When did you commence to be foreman and when did you cease to be foreman?

439 A. I commenced in December of 1877, and ceased to be foreman in February, 1881.

10 x-Q. Do you recollect seeing Mr. Edison make any experiments in electric lighting with carbonized paper during the time that you was foreman?

A. Yes, sir.

11 x-Q. When did you first witness such an experiment?

A. The earliest I remember was in 1879.

12 x-Q. What time was it in 1879?

440 A. I think it was in summer.

13 x Q. What was the experiment?

A. Paper carbon horseshoe, substantially like this in Exhibit Edison's Commercial Incandescent Electric Lamp.

14 x-Q. Do you recollect seeing Mr. Edison experiment with carbonized paper in this lamp marked Edison's Exhibit First Incandescent Lamp?

A. I do not recollect it.

15 x-Q. State where you first saw that lamp?

A. In Newark, N. J.

16 x-Q. When?

A. Before we moved to Menlo Park. 441

17 x-Q. What was it used for?

A. It is used with an air pump for experiments.

18 x-Q. Have you seen the lamp frequently since?

A. No.

19 x-Q. Did you ever see it in the laboratory at Menlo Park?

A. I recollect to have seen it at Menlo Park; yes, sir.

20 x-Q. Whereabouts did you see it in Menlo Park—in the laboratory? 442

A. Yes; in that building which we call the laboratory.

21 x-Q. Whereabouts was it kept in the laboratory?

A. I don't know that it ever had a certain place.

22 x-Q. Was it in plain sight most of the time?

A. Yes, sir; I think so. Everything was in plain sight. There was nothing stowed away.

23 x-Q. During the time that you was machinist, 443 and before you became foreman, was you frequently and constantly going in and out of the laboratory as a workman?

A. Yes, sir.

24 x-Q. And the same is true during the time that you was foreman?

A. Yes, sir.

25 x-Q. Did you put these binding posts on this lamp, Edison's first incandescent lamp?

A. No; I did not put them on personally. 444

26 x-Q. Did you see them put on?

A. No; I do not recollect.

27 x-Q. Do you know who put them on?

A. No; I do not recollect who put them on.

28 x-Q. Do you know when they were put on?

A. No.

29 x-Q. Who did you have in the machine shop at Menlo Park that done that kind of work during the time that you was machinist there?

A. I had several workmen at that kind of work.

445 30 x-Q. Please to give the names of those workmen, and where they are now.

A. Rudolph Heuse, who is dead. Echron, I don't know where he is. I think his first name was Albert, but am not quite sure. Baer was the name of another. I don't remember his first name, and I don't know where he is.

31 x-Q. Referring now to Edison's Exhibit No. 4, do you know in whose handwriting it is?

A. Yes, I recognize it as Mr. Edison's own hand-
446 writing.

32 x-Q. When was it written?

A. I think previous to that date there, or at the time of that date.

33 x-Q. Do you know of your own knowledge that it was written then?

A. No, I do not.

34 x-Q. Have you a distinct recollection of the experiments referred to by this paper?

A. No, sir.

447 35 x-Q. Have you such a recollection of them as to enable you to state when they were made?

A. No.

36 x-Q. At the time you signed this paper, was that piece torn out between your name and Mr. Batchelor?

A. I do not recollect, but I don't think so.

37 x-Q. Do you recollect whether anybody else's name was signed between yours and Mr. Batchelor's?

448 A. I do not recollect.

Cross examination ended.

RE-EXAMINATION BY GEORGE W. DYER, COUNSEL FOR EDISON.

38 Q. How early do you remember seeing the lamp, Edison's Exhibit First Incandescent Lamp,

with the binding posts on it, and the clamps inside of it? 449

A. I couldn't state the date. I recollect the lamp from general appearance.

JOHN KRUESI.

The taking of further testimony herein was adjourned by consent to Tuesday, June 28th, 1881, at 10 o'clock.

WM. H. MEADOWCROFT,
Notary Public, 450
N. Y. Co.

Pursuant to adjournment this testimony was continued June 28th, 1881, at 10 A. M., at same place, the same counsel being present.

FRANCIS R. UPTON, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows, in answer to questions proposed to him by George W. Dyer, counsel for Edison. 451

1 Q. Please state your age, residence and occupation?

A. Age twenty-eight; residence Menlo Park, N. J.; occupation manufacturer of electric lamps.

2 Q. State whether at any time you went into the employment of Mr. Edison, and what your duties were?

A. I entered the employment of Mr. Edison about November, 1878. I can fix the date exactly by reference to my accounts, and will do so. My first occupation was making a search through the records 452
of Electric Lighting in the Astor Library. When this was completed to Mr. Edison's satisfaction, I entered his employ at Menlo Park to assist him in making calculations.

3 Q. What special training or acquirements had you for making such calculations?

A. Before entering college and while in college I gave special attention to the mathematical branches. After leaving college I

[NOT FILMED: PAGES 114-129 (FRANCIS R. UPTON'S TESTIMONY). SEE EDISON ELECTRIC LIGHT CO. v. UNITED STATES ELECTRIC LIGHTING CO., VOL. 5.]

517 74 x-Q. Which one of the patents granted to Sawyer and Man is "for a stick of carbon rendered incandescent in nitrogen?"

A. In answer to the question I refer to the patent 205,144.

75 x-Q. Now please to point out the claim in that patent that is "for a stick of carbon rendered incandescent in nitrogen?"

A. Claim 16 is the one that I referred to more especially, which reads, "In the sealed globe of an
518 electric lamp which contains an azotic or other atmosphere, an absorbent of carbonic acid gas," together with the following in the body of the specification, "To charge our lamp we prefer to employ nitrogen gas, and this we produce in the lamp by our improved process in a state of great purity."

76 x-Q. Now, after reading the claim and the extract from the specification, don't you think your statement in your magazine article is too broad?

A. Not in a mere brief summary of the history of
519 electric lighting, as is purported to be given in the article.

77 x-Q. Do you swear that the statement in the magazine article, of the Sawyer and Man patent, is an accurate statement of the facts as they appear in the patent?

A. The patent itself is the best evidence of what it contains. If what I stated is right it can be verified from the patent.

520 FRANCIS R. UPTON.

Postponed by consent to Thursday, June 30th, 1881, at same hour and place.

WM. H. MEADOWCROFT,
Notary Public,
New York County.

Pursuant to adjournment this testimony was con- 521
tinued June 30th, 1881, at the same place, same counsel being present, and also Mr. Edison, one of the parties to this interference.

MR. KRUESI recalled.

39 Q. I asked you in question 5, "what is the earliest date which you remember of Mr. Edison's experimenting with electric lights," to which you answered, "I am not sure whether it was the summer of '77 or summer of '78" Please state whether
you have made such examination of memorandum 522
books since giving the above answer, as will enable you to fix the time more definitely?

Objected to on the ground that it is a re-examination of the witness on a point about which he had already been examined.

JOHN KRUESI, a witness produced in behalf of Mr. Edison, testifies on oath as follows, in answer to questions proposed by George W. Dyer, counsel for Edison:

40 Q. Have you been previously examined in this 523
case?

A. Yes.

41 Q. Since your former examination have you found a memorandum book which enables you to fix with certainty dates about which you were uncertain when you testified before?

Question objected to upon the ground that it is intended to call out matter and facts about which the witness has been already ex-
amined. 524

A. Yes, sir.

42 Q. Refreshing your memory by such memorandum book, what is the earliest date you are able to fix in which Mr. Edison was engaged in experimenting upon electric lights?

Objected to as immaterial.

A. January the 5th, 1877.

43 Q. If you have such memorandum book, please produce it and describe what the book is?

Objected to as immaterial and impertinent.

525 A. I do produce the book. The book is a memorandum book in which I put the time down for which I requested pay, showing how the time, or in what the time was occupied.

44 Q. Is this book in your own handwriting?

A. Yes, sir.

45 Q. Were the entries made at the time marked in the book?

A. They were always made never later than the next following Saturday, and generally every day;
526 sometimes even three or four times in one day.

46 Q. Please read from the book the items which bear upon experiments in electric lights by Mr. Edison, giving the dates which appear in the book?

Objected to as incompetent to prove the contents of the book, unless the book is put in evidence.

A. "January 5th, 1877, Electric Lamp, 3 hours." "January 6th, 1877, Electric Lamp, 4 hours." "1877, January 20, air pump, 8 hours."

527 47 Q. For what purpose was the work done on this air pump under the date of January 20th?

A. To my best recollection for an electric light purpose.

Memorandum book referred to put in evidence and marked Edison's Exhibit No. 12.

Exhibit objected to as incompetent evidence upon any issue in the cause.

Counsel for Edison gives notice that he here con-
528 cludes his examination of this witness and offers him to counsel for Sawyer and Man for cross examination.

CROSS-EXAMINATION BY AMOS BROADNAX, COUNSEL FOR SAWYER AND MAN:

48 x-Q. Is this book in your handwriting, the whole of it?

A. Yes; I don't see anything that isn't my own handwriting.

49 x-Q. In whose employ were you when you made this memorandum book?

A. In Mr. Thomas A. Edison's.

50 x-Q. And does this book show the time that 529
you was at work on different kinds of work for Mr. Edison?

A. Yes, sir.

x-Q. 51. Where was you working from June the 13th, 1876, to January 2d, 1877?

A. I was working for Mr. Edison in Newark, N. J.

52 x-Q. Are all the entries in this book made in lead pencil?

A. All except a few entries in the last four leaves 530
of the book, and three entries in October, 1875.

53 x-Q. Referring now to the entries in this book made on the page beginning with January 2d, 1877—do you swear that the entries on that page are all in your own handwriting, and that they were made by you on the day of the date set down in the left-hand column of the page?

A. Yes, I am positive that they are all in my own handwriting, and that they are put down not later
than the next following Saturday to these respec- 531
tive dates, or on the same day that they are dated.

54 x-Q. Does the column of figures on this page headed Particular Jobs represent the number of hours you were employed each day upon the job mentioned in the middle columns, in which the name of the job is given?

A. Yes, sir.

55 x-Q. Does this represent your own time, and not the time of somebody else?

A. It is only my own time. 532

56 x-Q. By this book it appears that January 5th you worked three hours on electric lamps. What kind of electric lamp was you working on, and what was you doing to it during those three hours?

A. I do not remember the lamp, nor exactly what I did to it.

57 x-Q. Is the same true as to the work it appears that you done on electric lamp on January 6th—4 hours?

A. Yes, sir.

533 58 x-Q. Is this your book?
A. Yes, sir.
59 x-Q. Your own private property?
A. Yes, sir.
60 x-Q. Has it been in your possession ever since it was made?
A. It has been in my possession ever since I made the entries.
61 x-Q. Why didn't you refer to this book and produce it when you was previously examined in
534 this case?
A. I was called to this examination from my place of business in the City of New York, and the book I kept in my house at Menlo Park, New Jersey. Therefore I did not have it at hand.
x-Q. 62. Have you got any more books bearing upon this subject?
A. Yes, sir. I have some more, but to my knowledge they do not bear upon this subject.
63 x-Q. How does it happen that there are no en-
535 tries in this book from June 13, '76, to January 2d, '77?
A. The entries may be in another book, on account of the dissolving of partnership between Mr. Edison and Mr. Murray at that time.

JOHN KRUESI.

THOMAS A. EDISON resumes his testimony as fol-
536 lows, this 30th day of June, 1881:
375 Q. In your answer to question 374 you have not stated the nature of the duties of the assistants employed by you. Please do so now?
A. Francis Jehl was employed generally to assist in any kind of experiments. John Kruesi was foreman of the machine shop; Charles Clarke, mathematician and mechanician; Charles Batchelor, principal assistant on general experimenting; William Hammer, assistant on vacuum pumps; Mr. Herrick, time-keeper for the lamps; Dr. Haid and Mr.

[NOT FILMED: PAGES 135-181 (EDISON'S TESTIMONY: CHARLES BATCHELOR'S TESTIMONY. SEE EDISON ELECTRIC LIGHT CO. v. UNITED STATES ELECTRIC LIGHTING CO., VOL 5.]

725 needed no further explanation from him as to what he proposed to do.

CHAS. BATCHELOR.

By consent, the taking of testimony was postponed to Wednesday, July 13th, 1881, at same place, at ten o'clock A. M.

WM. H. MEADOWCROFT,
Notary Public,
New York County.

726

Parties met, pursuant to adjournment, on Wednesday, July 13th, 1881, and adjourned by consent to Saturday, July 16th, 1881, at 10 o'clock A. M., at same place.

WM. H. MEADOWCROFT,
Notary Public,
N. Y. Co.

727

Parties met, pursuant to adjournment, on Saturday, July 16th, 1881, and adjourned by consent to Wednesday, July 20th, 1881, at 10 A. M., at same place.

WM. H. MEADOWCROFT,
Notary Public,
N. Y. Co.

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728 Pursuant to adjournment, this testimony was continued Wednesday, July 20th, 1881, at 10 A. M., same counsel being present.

STEPHEN D. FIELD, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows, in answer to questions proposed to him by George W. Dyer, counsel for Edison:

1 Q. Please state your name, age, residence and occupation?

A. Stephen Dudley Field; 35 years old; residence, New York; occupation, electrical engineer.

2 Q. Please state whether or not you visited Mr. 729
Edison at Menlo Park, in 1877, and if so, at what
time during that year?

A. I visited Mr. Edison's place during the summer of 1877. To the best of my recollection it was the middle or latter part of the month of August.

3 Q. When at Menlo Park, at the time named, did you see Mr. Edison perform any experiments in incandescent electric lighting, and if so, please state what the experiments were?

Question objected to as going to prove that 730
the invention was made before the date alleged in the preliminary statement of Mr. Edison, and notice of motion to strike it out at the hearing.

A. I went there at Mr. Edison's invitation to witness experiments in incandescent lighting. The experiment consisted in the heating, by means of a bi-chromate battery, of small crystals, of what Mr.
Edison called silicon, said crystals being supported
between carbon clamps. 731

4 Q. Please examine exhibits marked Edison's Exhibits No. 4 and No. 13, already in testimony in this case, and state whether or not these exhibits indicate substantially the character of the experiments which you then witnessed?

Objected to as immaterial and incompetent. Notice of motion to strike out.

A. The experiments which I witnessed are indicated in Figures 1 and 2 of Exhibit 4, and the mid-
dle and lower Figures of Exhibit No. 13. The ex- 732
ception being that the source of power in the experiments was a bi-chromate battery in place of magneto machines, as shown in the exhibit.

5 Q. During that visit to Mr. Edison, did he explain to you what he had previously done in incandescent electric lighting, and if so, what explanation or information did he give?

Same objection and same notice.

A. My recollection is that he stated that this use of silicon he hoped would give him an inoxidizable

733 agent for a burner, and thereby greatly simplify the problem of incandescent lighting. Beyond that I have no recollection of any conversation between us, except he referred to a note book which he showed me, wherein he had first discovered the incandescent properties of silicon.

6 Q. Do you recollect whether or not Mr. Edison spoke of materials for incandescent conductors, which had been previously tried by him and found to be oxidizable?

734 Same objection and same notice.

A. My recollection is that we had a general conversation on the subject, the details of which have, however, almost entirely escaped my memory.

7 Q. Who was present during these experiments you have mentioned, besides yourself and Mr. Edison?

Same objection.

A. Dr. Cornelius Herz, now in Paris, and Mr. Batchelor, I believe, and one or two of Mr. Edison's
735 assistants.

Counsel for Edison gives notice that he here closes his examination of this witness, and offers him for cross-examination.

NO CROSS-EXAMINATION.

STEPHEN D. FIELD.

THOMAS B. STILLMAN, a witness produced in behalf
736 of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed by GEORGE W. DYER, counsel for Edison:

1 Q. Please state your name, age, residence and occupation?

A. Thomas B. Stillman; 29 years old; residence, Plainfield, N. J.; occupation, analytical chemist and assayer.

2 Q. Please state whether or not you are acquainted with William E. Sawyer, the electrician?

A. I am.

3 Q. Please examine the paper I now show you, 737
marked Edison's Exhibit No. 8, and state whether or not you read the same soon after its publication in the newspapers?

Objected to as immaterial.

A. I have examined the paper shown me; I read it; it might have been one month, but not later than three months, after its publication?

4 Q. Did you ever hear William E. Sawyer speak of the authorship of that article, marked Edison's
Exhibit No. 8? 738

Same objection.

A. I have

5 Q. How often have you heard him so speak?

A. Once, certainly; and I think twice.

6 Q. Repeat what he said as nearly as you can remember it?

Objected to as incompetent and immaterial.

A. I can't state what he said; he called my attention to the article, and asked me if I had read it.
I said "No." I then read it. 739

7 Q. How did he speak of it—as his article?

Objected to as leading.

A. I can't say that he did. My impression is he said "my challenge."

8 Q. Do you remember what he said when he asked you to read the article?

A. I don't recollect any more than what I have said, positively.

9 Q. Have you heard the article referred to in his
presence as his article? 740

Objected to as incompetent.

A. Not in those words as coming from him, but the impression derived from what he said led me to think he wrote the article.

10 Q. Have you heard the article referred to in his presence, as his challenge, or as Sawyer's challenge to Edison?

Objected to as incompetent.

A. Not by other parties, but when Mr. Sawyer drew my attention to it as his challenge.

741 11 Q. Are you acquainted with Mr. William E. Sawyer's signature?

A. Yes, sir.

12 Q. Please examine the paper now shown you; state whether or not the signature, W. E. Sawyer, is in the handwriting of William E. Sawyer?

Objected to as incompetent.

A. I think it is—yes, sir.

13 Q. Have you any papers in your possession in the handwriting of William E. Sawyer, containing
742 his signature?

Objected to as incompetent and immaterial.

A. I have.

14 Q. Please produce the same?

Same objection.

A. I produce a note sent to me by William E. Sawyer.

The paper first mentioned is put in evidence and is marked Edison's Exhibit No. 23.
743 Exhibit 23 objected to as not being shown to be in the handwriting of Mr. Sawyer, or caused to have been written by him, and as not being produced by the person to whom it is addressed; and as incompetent, irrelevant and immaterial.

Second paper referred to, being a note to the witness, is put in evidence, and marked Edison's Exhibit No. 24.
744 Objected to as incompetent, irrelevant and immaterial.

15 Q. Please state if you find the newspaper article put in evidence, and marked Edison's Exhibit No. 23, published in the New York Sun of January 5, 1880?

Objected to as incompetent, irrelevant and immaterial; and upon the further ground that there is no proof that the paper put in evidence was January 5, 1880.

A. I find it published in the paper dated on that date—January 5, 1880. 745

16 Q. Also, is the paper now shown you the same extract cut out of the newspaper?

A. Yes.

Extract referred to put in evidence and marked Edison's Exhibit No. 25.

Objected to as incompetent and no proof of anything except its own existence.

17 Q. Were you subpoenaed as a witness in this case for Mr. Edison? 746

A. I was.

Counsel for Edison here closes his examination of this witness and offers him for cross-examination.

Cross-Examination by Amos Broadnax, Esq., Counsel for Sawyer & Man:

1 x-Q. When was this paper marked Exhibit 24 written?

A. I can't give the date of it.

2 x-Q. How do you know this paper is in the 747
handwriting of Mr. Sawyer?

A. It is the same handwriting I have always seen him use.

3 x-Q. How often have you seen him write, if at all?

A. A number of times; I can't state exactly how many.

4 x-Q. About how many?

A. I couldn't state about how many; I have been connected with him nearly three years. 748

5 x-Q. Can you swear that you saw Mr. Sawyer write ten times in these three years?

A. Yes, sir.

6 x-Q. And use the same handwriting every time?

A. Yes, sir; with one exception—when he couldn't see.

7 x-Q. Did you see him write when he couldn't see?

A. I did not. He had injured his eyes by an ex-

749 plosion. I had a note written from him when his eyes were in that condition, where he stated that fact. That note was in a different handwriting.

8 x-Q. In whose handwriting is this paper, Edison Exhibit 23?

A. I don't know; it looks like Sawyer's uncle's Leonard Sawyer.

9 x-Q. Did you see Mr. Sawyer sign this paper?

A. No, sir.

10 x-Q. It's not in the handwriting of Mr. Saw-
750 yer, is it?

A. No, sir.

11 x-Q. Do you know whether Mr. Sawyer read it or heard it read after it was written?

A. I do not.

12 x-Q. Do you know whether he dictated it?

A. I do not.

13 x-Q. Is this the paper Mr. Sawyer referred to as his challenge to Mr. Edison?

A. No, sir; the paper he referred to as his chal-
751 lenge to Mr. Edison is Edison's Exhibit No. 8.

14 x-Q. Do you know who wrote this paper Exhibit No. 8?

A. No, sir.

THOS. B. STILLMAN.

WILLIAM SAWYER, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows,
752 in answer to questions proposed to him by George W. Dyer, counsel for Edison.

1 Q. Please state your name, age, residence, and occupation?

A. Name, William Sawyer; age, 59; present location, Earle's Hotel; occupation, gentleman, as near as I can act one.

2 Q. Are you the father of William E. Sawyer, the electrician?

A. Yes.

3 Q. Please examine the paper now shown you

which is marked Edison's Exhibit No. 8, and state 753
whether you read the same soon after the date of its publication?

Objected to as incompetent, irrelevant, and immaterial.

A. I think I read that, about the time of its publication. I couldn't swear positively that this is the same thing, but think it is virtually the same. It was a challenge.

4 Q. Did you ever hear your son, William E. Saw-
yer, deny being the author of this challenge? 754

A. No, sir; nor I never heard him acknowledge it.

Latter part of the answer objected to by counsel for Edison as not responsive.

5 Q. Have you not stated within a week that your son, William E. Sawyer, wrote this challenge before referred to?

Objected to as incompetent.

A. I may have made that remark. I couldn't say that I did not. I have no recollection of making that remark, neither will I say that this is the chal-
lenge, shown me, that he wrote. 755

6 Q. Have not you stated within a week, that you went into a certain place, and found your son dictating this challenge to a messenger boy?

Objected to as also being incompetent.

A. Emphatically, no. I may have stated that I understood that he did dictate to a messenger boy and the messenger boy wrote it down as it came from his lips, but not from my personal knowledge.
It was hearsay. 756

7 Q. From whom did you understand that William E. Sawyer dictated that challenge to a messenger boy.

A. I couldn't tell; not within my recollection.

8 Q. Did you ever hear this challenge talked over in the presence of William E. Sawyer?

A. No, sir; to the best of my recollection, I never heard the subject matter talked over in his presence, either with myself or any other parties.

9 Q. Have you not stated within a week, that you

757 advised your son William E. Sawyer that he ought not to have published the challenge referred to, or so advised him at the time the challenge was being dictated?

Objected to as leading and immaterial.

A. I do not recollect of doing so.

10 Q. At what place did you understand this challenge, so called, was dictated?

A. According to the best of my recollection he was boarding at 200 West Forty-second street, at
758 the time of this publication.

11 Q. I do not ask where he was boarding, but where, as you understand it, he was when this challenge was dictated.

Question objected to as calling for hearsay evidence, and upon the further ground, that the witness has not stated that he understood the challenge to be dictated at all.

A. I have answered this question before. He may, however, have been boarding at 267 instead
759 of 200 West Forty-second street. My present impression is, that it was dictated either at 200 or 267 West Forty-second street. I would not state positively to either place, as I have no means of fixing it.

12 Q. Have you not stated within a week, that that challenge was dictated at the corner of Walker and Elm streets?

Objected to as grossly leading and immaterial.

A. I have no recollection of it.

760 13 Q. Have you any recollection of talking with anyone whatever about this challenge within a week?

A. I have no recollection of it.

14 Q. You stated conversationally, a moment ago, did you not, that you were very much annoyed when you read this challenge in the newspapers?

Objected to as leading and immaterial.

A. I did so state confidentially to Mr. Dyer.

15 Q. Had you any doubt at the time of reading

this challenge that it proceeded from your son, William E. Sawyer? 761

Objected to as leading and immaterial, as to what his opinion was, or doubts upon the subject.

A. Of course, I took it for granted, as all others would, the communication being over his signature.

16 Q. Were you subpœnaed as a witness in this interference?

A. Yes.

Counsel for Edison closes his examination of this witness, and turns him over for cross-examination. 762

Cross examination by Amos Broadnax, Esq., Counsel for Sawyer and Mann:

17 x-Q. Do you know of your own knowledge, whether your son, William E. Sawyer, wrote or dictated this article, cut from a newspaper, and marked Edison's Exhibit No. 8?

A. No. 763

Wm. Sawyer.

James A. Russell, a witness produced in behalf of Mr. Edison, being duly sworn, testifies as follows in answer to questions proposed to him by George W. Dyer, counsel for Edison:

1 Q. Please state your name, age, residence and occupation? 764

A. Residence 347 West Thirty-sixth street, New York; I am a canvasser for the Edison Electric Light Company. My name is James A. Russell, and I am 44 years of age.

2 Q. State whether or not you know Mr. William Sawyer, who has just testified as a witness in this case and in this room?

Objected to as immaterial.

A. Yes, I know him.

3 Q. State whether or not you have heard Mr.

765 William Sawyer lately make any statements regarding the authorship of a newspaper challenge published in the New York "Sun," December 22d, 1879, marked Edison's Exhibit No. 8, and if so, when and where were such statements made, and what was the statement?

Objected to as calling for mere heresay testimony, at second or third hand, and after the witness, William Sawyer, has testified that he really didn't know anything about it.

766 A. On Sunday last at Earle's Hotel, talking with Mr. Potter. Mr. Potter had a conversation with him about a man named William Sharpe, who had formerly been in the employ of William E. Sawyer. Mr. Potter said he would like to hire him as he was an expert mechanic. He said he wanted to hire him for a gentleman friend of his in Reading, Pennsylvania. This man wanted him to do some very fine work. That was his object in calling on Mr. Sawyer.

767 Mr. Sawyer said, "Do you know how that article was written?" He said, "Ed. was drunk, and it was written by a District Telegraph boy at his dictation, and he told Ed. he had made a mistake," and Ed. says, "I've done it, I've done it. They can't answer it." I don't know that he said he was drunk, but that he was a little off.

4 Q. What article was referred to in the last part of your answer?

A. The challenge, Edison's Exhibit No. 8. I

768 want to add to my last answer that Mr. Sawyer said, "Ed. slings a nasty pen, and talks too much."

Counsel for Edison closes his examination of this witness and offers him for cross-examination.

CROSS-EXAMINATION BY AMOS BROADNAX, ESQ., COUNSEL FOR SAWYER AND MAN:

5 x-Q. At the time you overheard this conversation which you have related in your examination-in chief, did Mr. Potter show Mr. Sawyer this exhibit?

A. No.

6 x-Q. How did he identify the article? 769

A. He mentioned the fact that the article was written in the "Sun" just before Christmas.

7 x-Q. Did he say that he saw his son dictate the article?

A. Yes.

8 x-Q. How did you come to go there?

A. I went to H. Dralle, 93 Walker street, and he told me that William Sawyer, Sr., could give me all the information. 770

9 x-Q. What did you want of Mr. Sharpe?

A. I wanted some excuse to have an interview with Mr. Sawyer.

10 x-Q. And the object of your interview, as I understand you, was to see what you could suck out of him about this matter?

A. Not to suck out of him, but to obtain anything I could that would benefit my employers.

JAMES A. RUSSELL.

771

JAMES D. POTTER, a witness produced in behalf of Mr. Edison, testifies as follows, in answer to questions proposed to him by George W. Dyer, counsel for Edison.

1 Q. Please state your name, age, residence and occupation?

A. James D. Potter; age, 57; residence, 390 Manhattan avenue, Brooklyn; I am engaged in mining. 772

2 Q. Are you acquainted with William Sawyer, who has just testified in this case and in this room?

A. I am acquainted with the gentleman who calles himself William Sawyer. I have just come in this building and did not see Mr. Sawyer here.

3 Q. Have you had a conversation with William Sawyer lately about the authorship of an article called a challenge, published in the New York *Sun*, December 22d, 1879, marked Edison's Exhibit No.

773 8, and if so, when and where did you have this conversation, and if anybody was present besides yourself and Mr. Sawyer, state who was present?

Question objected to as calling for mere hearsay testimony, as contradicting the statement made by one of Mr. Edison's own witnesses.

A. It was on Sunday, July 17th, at 2 o'clock, at Earle's Hotel; Mr. James A. Russell was present.

4 Q. Please state what Mr. Sawyer said in regard
774 to the authorship of the article referred to in the former question?

A. We had a conversation in regard to a man named William Sharpe, desiring to know his locality, as I wished to hire him for a gentleman in Reading. He informed me where Sharpe could be found; said he was at Ansonia, Connecticut, employed by the Wallace Manufacturing Company. Then the conversation drifted off to electricity. He said, "Ed. was one of the best electricians in
775 the United States." I told him I had read many articles of his son's about electricity, electric light, etc. He said, "Did you read that challenge in December, '79?" I said, "Yes, sir;" and also said "that never was answered." He replied, "He couldn't answer it." He then said, "Do you know how that was written—under what circumstances?" I said, "No, I do not." He said, "I'll tell you. Ed. got a telegraph boy to write it." He said, "he was pretty full," or "he was drunk:" one or both
776 expressions. "While he was dictating it he would fall asleep or doze off. He would wake up and ask 'Where did I leave off? What did I say last?' The boy wrote the article, and that was the way he wrote it." He was writing the article when Sawyer came in. He said to him, "Ed., do you think you're doing right?" He said, 'Yes, I've done it, I've done it. They can't answer it.'"

Examination ended. No cross-examination.

JAMES D. POTTER.

JAMES E. O'KEEFFE, a witness, produced in behalf of Mr. Edison, testifies as follows in answer to questions proposed by George W. Dyer, counsel for Edison. 777

1 Q. Please state your name, age, residence and occupation?

A. James E. O'Keeffe of 65 Monroe street, New York; office boy to the Aldine Publishing Company; age 15.

2 Q. What were you doing before you went in the office of the Aldine Publishing Company? 778

A. Working in E. Daly's boat shop.

3 Q. Where before that?

A. With Matthew, Leach & Co.'s wholesale and retail tea store.

4 Q. Were you ever in the employ of the American District Telegraph Company. If so, when and where?

A. In the 15th District, from May, 1879, until February, 1880.

5 Q. Look at this newspaper article I show you, 779 which is marked Edison's Exhibit No. 8, and state what you know, if anything, about that article?

A. I remember hearing him speak about a challenge, and there was words in it that I couldn't spell and he told me how to spell them—big words.

6 Q. Did you write that article from anybody's dictation?

A. Yes, sir.

7 Q. When was it; and where was it?

A. In Dralle's lager beer saloon, corner of Elm 780 and Walker streets, in December, 1879, on Sunday morning.

8 Q. What did you do with the article after you wrote it from dictation?

A. I handed it back to Mr. Sawyer.

9 Q. Then what did you do with it?

A. He put it in an envelope, and I went up to the Sun office.

10 Q. Did you leave the paper at the Sun office?

781 A. Yes, sir, and I brought back an answer.

Counsel for Edison closes his examination-in-chief of this witness, and gives him over for cross-examination.

Cross-examination by Amos Broadnax, Counsel for Sawyer and Man.

11 x-Q. Was the article you wrote from Mr. Sawyer's dictation printed in the "Sun?"

A. I don't know ; I didn't see it?

782 12 x-Q. Can you produce the paper that you wrote from Mr. Sawyer's dictation?

A. No, sir.

13 x-Q. When did you read that paper—Edison's Exhibit S?

A. To-day.

14 x-Q. Is that the first you read it since you wrote it from Mr. Sawyer's dictation?

A. Yes, sir.

15 x-Q. Now, can you swear that this paper, Ex-
783 hibit S, is a copy of the paper that Mr. Sawyer dictated to you, as you have stated?

A. I can't say that it's all, but I know some of it is.

16 x-Q. After the paper was printed, did you compare the printed paper with the paper you say you wrote from Mr. Sawyer's dictation?

A. No, sir.

17 x-Q. Have you ever seen the paper that you wrote from Mr. Sawyer's dictation, and that you
784 took to the Sun office, since you took it to the Sun office?

A. No, sir.

18 x-Q. What was the answer that you brought back from the Sun office?

A. I don't know ; Mr. Sawyer didn't receive the answer, but the man behind the bar. Mr. Sawyer was up-stairs.

19 x-Q. Was Mr. Sawyer drunk when he dictated the paper to you?

A. He acted like it.

Re-direct examination by George W. Dyer, Counsel for Edison : 785

20 Q. Have you ever written any other paper from dictation for anybody else?

A. Yes, sir ; once before ; for a man down in New street.

James E. O'Keeffe.

Counsel for Edison gives notice that the testimony in behalf of Edison closes here. 786

Wm. H. Meadowcroft,
Notary Public,
New York County.

State of New York, }
City and County of New York. } ss. :

I, William H. Meadowcroft, a Notary Public, within and for the City and County of New York, and State of New York, do hereby certify that the 787
foregoing depositions of Thomas A. Edison, Martin N. Force, Edward H. Johnson, John Kruesi, Francis R. Upton, Charles Batchelor, Stephen D. Field, Thomas B. Stillman, William Sawyer, James A. Russell, James D. Potter, and James E. O'Keeffe, were taken on behalf of Thomas A. Edison, in pursuance of the notice hereunto annexed, before me, at No. 65 Fifth avenue, in the City of New York, on the 10th, 11th, 13th, 14th, 15th, 16th, 17th, 18th, 788
27th, 28th, 29th and 30th days of June, 1881, and the 7th, 8th, 9th, 13th, 16th and 20th days of July, 1881; that each of said witnesses was, by me, duly sworn before the commencement of his testimony; that the testimony of the said witnesses was written out by Henry W. Seely and Richard N. Dyer, they having been, by me, duly sworn to record the same faithfully; that Amos Broadnax, Esq., representing the opposing parties, Messrs. Sawyer and Man, was present during the taking of said testimony; that said testimony was taken at No. 65 Fifth avenue, in the City of New York, and was commenced at 11

789 o'clock A. M. at No. 65 Fifth avenue aforesaid, on the 10th day of June, 1881, and was continued, pursuant to adjournment, on the 11th, 13th, 14th, 15th, 16th, 17th, 18th, 27th, 28th, 29th and 30th days of June, 1881, and the 7th, 8th, 9th, 13th, 16th and 20th days of July, 1881; and was concluded on the last mentioned day; and that I am not connected by blood or marriage with either of said parties, nor interested directly or indirectly in the matter in controversy.

790 In testimony whereof I have hereto set my hand and affixed my official seal at No. 65 Fifth avenue, in the said County of New York, this 21st day of July, A. D. 1881.

WM. H. MEADOWCROFT,
[L.S.] Notary Public,
New York County.

791

792

[NOT FILMED: EDISON'S EXHIBITS, NO. 2, NO. 10, NO. 11. SEE EDISON ELECTRIC LIGHT CO. v. UNITED STATES ELECTRIC LIGHTING CO., VOL. 6.]

Edison's Exhibit No. 25. W. H. M. Notary Public, N. Y. Co.

Mr. Edison Chalenged by Mr. Sawyer.

To the Editor of the Sun—Sir: Notwithstanding the assertion that one of Mr. Edison's electric lamps has been running for 240 hours, I still assert, and am prepared to back up my assertion, that Mr. Edison can not run one of his lamps up to the light of a single gas jet (to be more definite, let us call it twelve-candle power) for more than three hours. To be still more definite, I offer to Mr. Edison, at 226 West Fifty-fourth street, in this city, an opportunity to prove what he says. From the private residence in that street wires are run a circuit of 1,000 feet. Mr. Edison shall have every facility; he shall use my wires; he shall have any dynamo machine or other generator of electricity he may prefer; and all I ask is that the power of his light shall be measured by a photo-metre; that, once in place, it shall not be interfered with; and that a committee of gentlemen, preferably nominated by the editors of the New York press, shall be present and certify to the facts of the test.

Furthermore, I will place one of my lamps side by side with Mr. Edison's; it shall be run at the power of twenty-five candles; it shall outlast the entire forty lamps at Menlo Park, run at the power of twenty-five candles; my lamp to stand as it is put up, and Mr. Edison to put up a fresh lamp as fast as the preceding lamp shall have burned out.

I am anxious for this test; and if Mr. Edison has really run one of his horse-shoe lamps 240 hours he will not refuse to accept my offer, for he will be treated with the utmost courtesy, and shall have everything his own way.

I adhere in every particular to my original challenge to Mr. Edison.

W. E. Sawyer.

78 Walker street, New York, Jan. 4.

—*The Sun*, Monday, January 5, 1880.

INTERFERENCE.

Sawyer & Man vs. Edison. } Electric Lamps.

BEFORE THE HONORABLE SECRETARY OF THE INTERIOR.

Brief for Edison in Support of his Appeal.

In this case reliance will be had upon the arguments submitted in behalf of Edison before the Commissioner of Patents, which arguments will be found in the printed briefs of Hon. Roscoe Conkling and of George W. Dyer, filed herewith and made a part of this brief.

These arguments will also be relied upon as to the errors in law and fact in the decision of the Commissioner, and set out in this appeal herewith submitted.

Roscoe Conkling,
Geo. W. Dyer,
For Edison.

October 29, 1883.

"COPY OF APPEAL.

INTERFERENCE.

SAWYER & MAN vs. EDISON. } Electric Lamps.

To the Honorable Secretary of the Interior:

In the above entitled Interference, I respectfully appeal to your honor from the decision of the Commissioner of Patents, who, on October 8, 1883, awarded priority of invention to Sawyer & Man, and assign the following

Reasons of Appeal.

The Commissioner erred in the following particulars:

As to Matter of Law.

1. In determining that if the inventions claimed by the respective parties, are not "substantially the same," or, if Sawyer & Man are not joint inventors, then the Interference must necessarily be dissolved.

2. In determining that the conductors of the respective parties were "substantially the same," because both employed paper, and both papers were adapted for use in incandescent electric lamps, without taking into consideration the other essentials which in law enter into the comparison of two things asserted to be "substantially the same," viz., a similarity in the mode of operation, and in the result attained.

Having found that Sawyer first suggested the use of paper for carbons for incandescent lamps, and that both Sawyer & Man participated in subsequent experiments in treating the paper after it was carbonized,

3. in determining that under such circumstances Sawyer & Man were joint inventors of carbon conductors made of paper.

Having found that Edison had made and used paper carbon conductors for electric lamps, and had decided that carbon had the requisite qualities of high resistance and small mass necessary to develop his theory,

4. in determining that Edison did not, in fact, invent his paper carbon conductors until such time subsequently, as he had ascertained from experiment the best size for his filaments and had devised a better mode of creating a vacuum in his lamps.

5. In determining that Sawyer & Man did not make the invention when their lamp had a life of a few minutes, but did make it when their lamp had a life of a few hours.

6. In determining that the letters and book of Sawyer were not proof of an abandonment of the invention of Sawyer & Man, because there was proof that Sawyer & Man had completed the invention before the letters were written.

7. In determining in effect that one of two joint inventors cannot abandon the common invention by public delarations known to and uncontradicted by the other intor.

As to Matter of Fact.

The case finding on uncontradicted testimony that the paper conductors of Edison had a resistance of one hundred ohms, and those of Sawyer & Man a resistance of one-fourth of an ohm,

1. in determining that these conductors were "substantially alike."

The case finding that Edison conductors were simply car-

bonized paper, where the paper gave the high electrical resistance and the consequent light, and Sawyer & Man's conductors were paper carbons built up by hydro-carbon deposits, where the deposits alone caused the low resistance, and alone gave the light,

2. in determining that these two conductors were "substantially alike."

3. In determining from the proofs that Sawyer & Man invented paper carbon conductors for incandescent lamps in 1878.

4. In determining from the proofs that Edison invented paper carbon conductors for incandescent lamps in 1879.

5. In determining that Sawyer & Man's paper carbons were perfected inventions.

6. In awarding priority of invention to Sawyer & Man contrary to the proofs in the case.

7. In not awarding priority of invention to Edison, in accordance with the proofs in the case.

In view of the pecuniary interests involved in this appeal, the Secretary is respectfully requested to grant an oral hearing.

THOS. A. EDISON
by GEO. W. DYER,
ROSCOE CONKLING.

WASHINGTON, D. C., *October* 17, 1883."

1

In the United States Circuit Court

FOR THE SOUTHERN DISTRICT OF NEW YORK. 2

THE EDISON ELECTRIC LIGHT COMPANY,
Complainant.

vs. In Equity.

UNITED STATES ELECTRIC LIGHTING COMPANY,
Defendant. 3

TO THE HONORABLE THE JUSTICES OF THE CIRCUIT COURT OF THE UNITED STATES FOR THE SOUTHERN DISTRICT OF NEW YORK.

The Edison Electric Light Company, a corporation duly organized and existing under and by virtue of the laws of the State of New York, and having its principal place of business in the City of New York, brings this its bill of complaint against the United
States Electric Lighting Company, a corporation like- 4
wise organized and existing under and by virtue of the laws of the State of New York, and having its principal place of business in the City of New York.

And thereupon your orator complains and says:

That, as your orator is informed and believes, prior to the 5th day of February, 1880, Thomas Alva Edison, a citizen of the United States, residing at Menlo Park, in the County of Middlesex and State of New Jersey, was the true, original and first inventor of a certain new and useful improvement in electric lamps

5 and holders for the same, which was not known or used in this country, and not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof, and which was not in public use or on sale more than two years prior to his application for Letters Patent of the United States therefor, and did on the said 5th day of February, 1880, apply to the Commissioner of Patents of the United States for letters patent for said invention or improvement and fully and in all respects complied
6 with all the requirements of the law in that behalf, and especially made oath that he verily believed himself to be the true, original and first inventor of the said improvement, and also paid into the Treasury of the United States the fees required by law, and presented to the said Commissioner of Patents a petition setting forth his desire to obtain an exclusive property in said improvement and praying that letters patent might for that purpose be granted unto him; and also delivered and filed in said office of the Commissioner of
7 Patents a written description of his said improvement in such full, clear and exact terms as to enable any person skilled in the art with which the said improvement is most nearly connected to make and use the same, which description was duly signed by the said Thomas Alva Edison and attested by two witnesses.

That the said Thomas Alva Edison, on the 21st day of June, 1881, and before the issuing of the letters patent next hereinafter mentioned, by an instrument in writing duly executed and delivered by him, and bear-
8 ing date on the last day named, did assign to your orator, and its successors and assigns, all the right, title and interest whatever in and to the said improvement in electric lamps and holders for the same, and any Letters Patent of the United States that might thereafter be granted therefor, and that said instrument in writing was duly recorded in the Patent Office on the 24th day of June, 1881.

That upon due examination being made as to the novelty and utility of the said invention or improvement by the Commissioner of Patents, as provided by

law, upon application for letters patent made as 9
before set forth by Thomas Alva Edison your orator, as the assignee of said Edison, was adjudged to be entitled to letters patent for said invention or improvement, and thereupon the said Commissioner of Patents caused letters patent, bearing date the 3d day of October, 1882, and numbered 265,311 to be made out, issued and delivered to your orator in due form of law in all respects, in the name of the United States of America, and under the seal of the Patent Office of the
United States, and that said letters patent were signed 10
by the Secretary of the Interior of the United States and countersigned by the Commissioner of Patents; and that the said letters patent did grant unto your orator, and its successors and assigns, for the term of seventeen years from the date thereof the exclusive right to make, use and vend the said invention throughout the United States and the Territories thereof.

And your orator further shows, on information and belief, that prior to the 26th day of March, 1881,
Thomas Alva Edison was the true, original and first 11
inventor of a certain other new and useful improvement in electric lamps and sockets or holders, not known or used in this country, and not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof, and which was not in public use or on sale more than two years prior to his application for letters patent of the United States therefor, and did on the said
26th day of March, 1881, apply to the Commissioner 12
of Patents of the United States for letters patent for said invention or improvement, and fully and in all respects complied with all the requirements of the law in that behalf, and especially made oath that he verily believed himself to be the true, original and first inventor of the said improvement, and also paid into the Treasury of the United States the fees required by law, and presented to the said Commissioner of Patents a petition setting forth his desire to obtain an exclusive property in said improvement, and praying that letters patent might for that purpose be granted unto him;

13 and also delivered and filed in said office of the Com-
missioner of Patents a written description of his said
improvement, in such full, clear and exact terms as to
enable any person skilled in the art with which the
said improvement is most nearly connected to practice
the same, which description was duly signed by the
said Thomas Alva Edison and attested by two wit-
nesses.

And that the said Thomas Alva Edison by said in-
strument, in writing, executed and delivered by him
14 June 21st, 1881, and duly recorded in the Patent Office,
June 24th, 1881, did also assign to your orator, and its
successors and assigns, all the right, title and interest
whatever in and to the said last mentioned improve-
ment in electric lamps, and sockets or holders, and any
Letters Patent of the United States that might there-
after be granted therefor.

That thereafter upon due examination being made as
to the novelty and utility of the said last-mentioned
improvement by the Commissioner of Patents, as pro-
15 vided by law, upon application for letters patent made
as before set forth by the said Thomas Alva Edison,
your orator, as the assignee of said Edison, was ad-
judged to be entitled to letters patent for the said in-
vention or improvement, and thereupon the said Com-
missioner of Patents caused letters patent, bearing
date the 27th day of December, 1881, and numbered
251,554, to be made out and issued to your orator, in
due form of law in all respects, in the name of the
United States of America and under the seal of the
16 Patent Office of the United States, and that said letters
patent were signed by the Secretary of the Interior,
and countersigned by the Commissioner of Patents;
and that said letters patent did grant unto your orator,
its successors and assigns, for the term of seventeen
years from the date thereof, the exclusive right to make,
use and vend the said invention throughout the United
States and the Territories thereof.

That your orator is now the sole and exclusive owner
of the two letters patent before mentioned, and of all
claims for infringement or violation thereof, and is

entitled to sue for and receive said claims to its own 17
use.

And your orator further shows that the improve-
ments described in said Letters Patent Nos. 265,311
and 251,554, and covered by the claims thereof
respectively, are capable of use, and are in fact used
by your orator and the defendant in one and the same
electric lamp for giving light by electrical incandes-
cence and its socket or holder.

And your orator further shows that it has expended
large sums of money in the perfecting of said inven- 18
tions and in the introducing of the same into public
use, and that the same are of great public utility.
That the fact that said Edison was the original and
first inventor of said inventions, and that the patents
above named are good and valid patents has been gen-
erally recognized and acknowledged by those who have
used the inventions, and the public generally in all
parts of the United States, and the claims of the said
Edison and your orator and its licensees of the exclu-
sive right to the said inventions under said patents 19
have been generally acknowledged and acquiesced in.

That there are now in use in the United States more
than one hundred and twenty thousand electric incan-
descent lamps and sockets licensed by your orator, and
that but for the infringement, misrepresentations and
wrongs hereinafter complained of, your orator would
now be in the peaceful possession and enjoyment of
said letters patent and inventions, and of the income
derivable therefrom.

And your orator further shows that said defendant 20
hereinbefore named as your orator is informed and
believes, having notice of said two letters patent and
well knowing all the facts hereinbefore set forth, but
contriving to injure your orator and to deprive it of
the benefit and advantage which might and otherwise
would accrue to it from said inventions, without the
license of your orator, against its will and protest, and
in violation of its rights, and of said letters patent and
each of them, has made, sold and used, and caused to
be made, sold and used, is now making, selling and

21 using, and causing to be made, sold and used, and intends still to continue to make, sell and use, and cause to be made, sold and used incandescent electric lamps and sockets embodying and involving the use of the improvements covered by said letters patent, and each of them, or substantial or material parts of them and each of them, and has infringed the said letters patent and each of them as aforesaid, and is now infringing the same in the Southern District of New York and elsewhere by making, selling and using,
22 and causing to be made, sold and used as aforesaid in the Southern District of New York and elsewhere the improvements covered by said letters patent and each of them, or substantial or material parts of them and each of them; but precisely how long the defendant has made, sold and used the said improvements, and to what extent it has made, sold and used them, your orator for want of a discovery thereof does not know and cannot set forth, and prays that the defendant may be compelled to set forth the same in
23 its answer.

That by reason of said infringement of said letters patent and each of them, as aforesaid, great injury has resulted to your orator, and great gains and profits have accrued to said defendant, the full amount of which is unknown to your orator; but your orator avers, on information and belief, that the defendant has so made and used, and caused to be made and used, a large number of such incandescing electric lamps and sockets, and that it has derived large profits
24 therefrom, and that your orator has been deprived of large gains and profits, by reason of the aforesaid infringement of the defendant, and has thus suffered large damages therefrom.

And your orator prays your Honors to grant unto your orator a permanent writ of injunction, issuing out of and under the seal of this Honorable Court, directed to the said United States Electric Lighting Company, and strictly enjoining it and its officers, agents and employees, not to make, or use, or sell, or cause to be made, used or sold, any incandescing electric lamps and

sockets containing or employing the inventions covered 25
by said Letters Patent Nos. 265,311 and 251,554, or either of them.

And your orator further prays that the defendant by a decree of this Court may be decreed to account for and pay over to your orator all such gains and profits resulting to it from said infringements of said letters patent or either of them, and also that the defendant may be decreed to pay all the damages which your orator has incurred or shall have incurred on account
of defendant's infringements of said letters patent or 26
either of them, and also that the defendant may be decreed to pay the costs of this suit, and that your orator may have such other or further relief as the equity of the case or the statutes of the United States may require and to your Honors shall seem meet.

To the end, therefore, that the said defendant may, if it can, show why your orator should not have the relief herein prayed, and may, upon the oath of its proper officers, and according to the best and utmost
of their knowledge, remembrance, information or belief, 27
full, true, direct and perfect answer make to all and singular the matters hereinbefore stated and charged as fully and particularly as if the same were here repeated and they especially interrogated as to each and every of said matters, and more especially may answer, discover and set forth whether during any, and at what period of time, and whether in the Southern District of New York, or elsewhere, and when and where they have used said improvements, or any one of them, and
whether they have manufactured, or sold, or used, or 28
caused to be manufactured, sold or used in said district, or elsewhere, any incandescing electric lamps and sockets containing or employing the inventions covered by said Letters Patent Nos. 265,311 and 251,554, or either of them, and how many such lamps and sockets they have made or sold, and to whom they have sold the same, and how and of what materials the said lamps and sockets and the several parts thereof are and have been constructed.

May it please your Honors to grant unto your orator

29 a writ of *subpœna ad respondendum*, issuing out of and under the seal of this Honorable Court and directed to the said United States Electric Lighting Company and commanding it to appear and make answer to this bill of complaint, and to perform and abide by such decree herein as to your Honors shall seem meet.

THE EDISON ELECTRIC LIGHT COMPANY,
By EUGENE CROWELL,
President.

30 JOHN C. TOMLINSON,
Solicitor.

WILLIAM M. EVARTS,
JOHN C. TOMLINSON,
RICHARD N. DYER,
Of Counsel.

31

32

STATE OF NEW YORK, } ss.: 33
County of New York, }

On this day of 1885, before me personally appeared Eugene Crowell, above named, and made oath that he is President of said the Edison Electric Light Company; that he has read the foregoing bill subscribed by him and knows the contents thereof, and that the same is true of his own knowledge, except as to matters which are therein stated to be based on information and belief, and as to 34
those matters he believes it to be true.

35

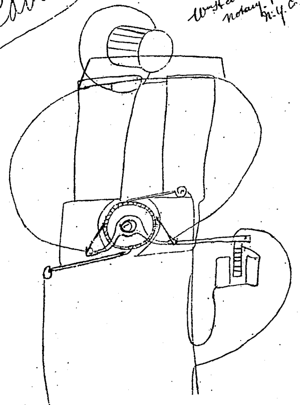
36

Jany 4 1881

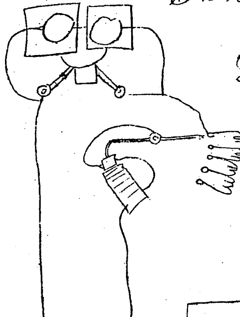
S D Mott

Caveat

Edison's Exhibit D
November 5, 1883
Wm H Meadowcroft
notary public
N.Y.C.

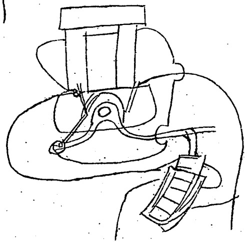


Jany 3d 1881 S D Mott



Caveat

Edisons Exhibit E.
November 5, 1883
Wm H Meadowcroft
Notary public
N.Y. Co



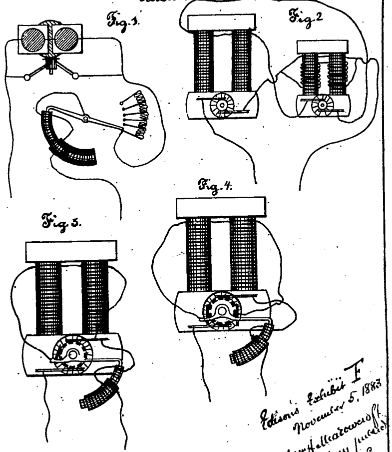
Caveat.

Fig. 1.

Fig. 2

Fig. 3.

Fig. 4.



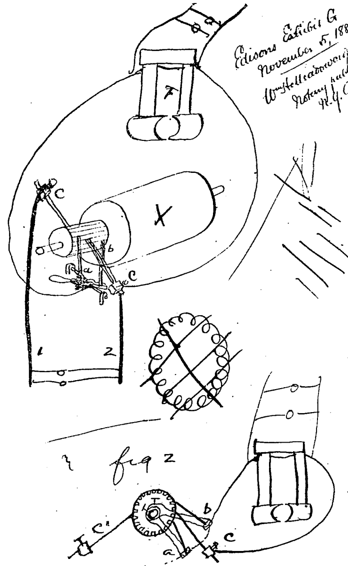
Edison's Exhibit F
November 5, 1883
Wm H[illegible]
Notary Public
N. Y. Co.

Attest

S. D. Mott

Inventor:

T. A. Edison



Edisons Exhibit G
November 5, 1883
Wm H Meadowcroft
Notary public
N.Y. Co

fig 1.

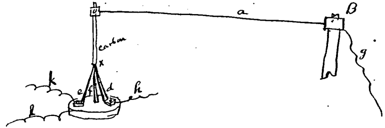
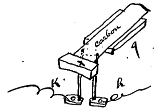


fig 2



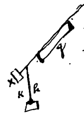


fig 2½

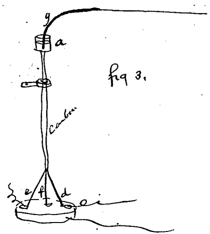


fig 3.

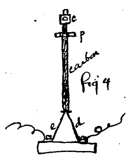


fig 4

Edison Exhibit 3.

3 Electric Light Copy of this on page 116. Vol 1. Expt Researches this 28 day of Sept. 1878 Wm Carman 3

Dec 3 1877
T A Edison

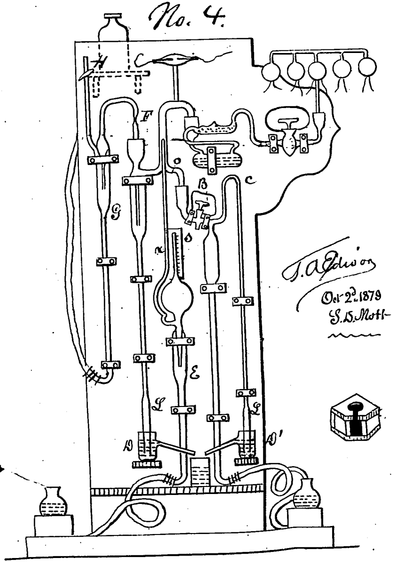
Such Experiments with Ruthenium & Silicon prove their adaptability to subdivision of the Light = It is possible to get good results by powdering the silicon & putting it in a glass tube passing the current through the powder

Chas Batchelor
M N Force
J Kruesi

(Edisons Exhibit No 5) 2

Edison's Exhibit No. 6.

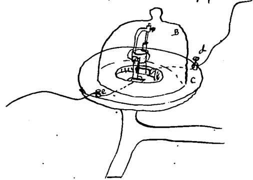
No. 4.



T. A. Edison
Oct 2d. 1879
S. D. Mott

Edison Exhibit No. 9

A fig.1.



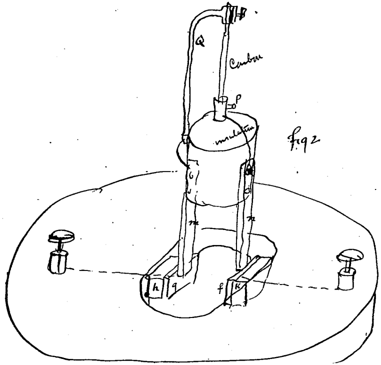


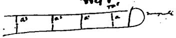
Fig 2

2 Electric Light

Nov 1877. 2
T A Edison
Chas Batchelor

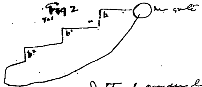
I have tried Boron Ruthenium Chromium and other J Kruesi
almost infusible metals for separators in my
Electric Light device - Boron is very high
resistance and would do for arrangement like

Fig 1



Silicon on the other hand
is very low resistance and would have to be arranged
thus

Fig 2



I think powdered Silicon mixed with
Lime or other very infusible non Conductor
or semi Conductor would be good thing

Copied in Vol No 1. Experimental Researches page 116 Sept 28. 1878
Wm Carman

Edison's Exhibit No 4

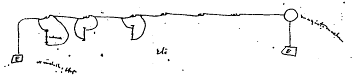
Electric Light

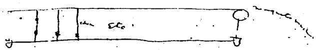
Oct 5 1877

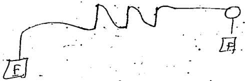
T A Edison

Chas Batchelor

No 1







Edison's Exhibit No 13 - W.H.M. Notary public. N.Y. Co

Mix metallic Silicon with Kaolin or Lime which will Cause them to glow

30

July 20 1877

1 – Hammered Aluminium
2 – Platina
3 – Silver
4 – Phosphor Bronze
5 – Zinc
6 – Lead
7 – French Steel
8 – Wrought iron
9 – Nickel
10 – Russian leather
11 – White spruce shellaced
12 – Light Mahogany
13 – Rose wood
14 – Brass
15 – Walnut wood
16 – paper of all kinds
17 – Celluloid
18 – Hard Rubber
19 – Vulcanized fibre
20 – Cardboard
21 – Carbon paper
22 – Copper foil
23 – Mica
24 – Bastie Glass
25 – Papier Maché
26 – Veneering of different woods
27 – Plaster of Paris
28 – Crocodile Skin
29 – Fish skin near tail (Mackerel)
30 – Paper barrel stock
31 – Iridium foil
32 – Collodionised paper
33 – Gelatin
34 – Oil board such as used for Copy press
35 – Soft rubber sheets
36 – Gold foil
37 – Thin slate
38 – Oil cloth

Chas Batchelor
James Adams

(Edison's Exhibit No. 14) W. H. M. notary public N.Y. Co.

Mr Edison Challenged by Mr Sawyer Office.

1880 – Jan 4

To the Editor of the Sun – Sir

Edison's Exhibit
No ~~2~~ 23 W.H.M.
Notary public
N.Y. Co.

~~78 Walker St~~
~~New York Jan 4 1880~~

~~Editor Sun~~

Notwithstanding the assertion that one of Mr Edisons electric lamps has been running for 240 hours I still assert, and am prepared to back up my assertion, that Mr Edison cannot run one of his lamps up to the light of a single gas-jet (to be more definite, let us call it 12 candle power) for more than three hours. To be still more definite I offer to Mr Edison, at 226 W 54th St in this city, an opportunity to prove what he says. From the private residence in that street, wires are run a circuit of 1.000 feet. Mr Edison shall have every facility; he shall use my wires; he shall have any dynamo electric machine or other generator of electricity he may prefer; and all I ask is that the power of his light shall be measured by a photometer; that, once in place, it shall not be interfered with; and that a Committee of gentlemen, preferably nominated by the editors of the N.Y. press

agate 8 K

shall be present and certify to the facts of the test

Furthermore, I will place one of my lamps side by side with Mr Edisons; it shall be run at a power of 25 candles; (it shall outlast the entire 40 lamps at Menlo Park run at the power of 25 candles;) my lamp to stand as it is put up, and Mr Edison to put up a fresh lamp as fast as the preceding ~~the~~ lamp shall have burned out.

¶ I am anxious for this test; and if Mr Edison has really run one of his ~~lamps~~ horse shoe lamps 240 hours he will not refuse to accept my offer, for he will be treated with the utmost courtesy and shall have everything his own way.

I adhere in every particular to my original challenge to Mr Edison.

Respy,
W. E. Sawyer

78 Walker street New York Jan 4

111

Dear [illegible] Please fill this bag and [illegible] gas, [illegible] [illegible] [illegible] first.

[illegible] [illegible] I [illegible]
When you [illegible] [illegible]
[illegible] [illegible] made [illegible] show me how to [illegible] the [illegible] [illegible] Also bring [illegible] [illegible] [illegible]

Truly W. E. Sawyer [illegible]

(Edison's Exhibit No. 24) W.H.M. [illegible] notary public N. Y. Co.

MISCELLANEOUS UNBOUND INTERFERENCES

Edison v. Gray & als. (1883)

This pamphlet contains an 8-page brief, filed on Edison's behalf by George W. Dyer, requesting the U.S. Board of Patent Examiners to reconsider its decision to grant Elisha Gray priority in the dispute over a patent application for a circuit breaker for electric generators. (See Edison v. Lane v. Gray v. Rose v. Gilliland [1882].) Portions of this decision have been quoted in the brief.

Before the Commissioner of Patents.

ON APPEAL.

Edison vs. Gray & als.	Interference. Magneto Electric Machines (Case A.)

Brief for Edison.

In this case the Board of Examiners in Chief determined that Gray was the prior inventor in the following

Opinion.

"Other applicants were involved in this interference, but dropped out on the decision of the Examiner of Interferences finding priority in Gray. Edison alone appealing.

"The matter in issue is declared to be:

"'The combination of a main circuit and a dynamo or magneto electric machine with a shunt or short circuit around the machine and means for automatically controlling and breaking such short circuit immediately upon and continuously during the operation of the machine.'

"The material matter consists in 'means for *automatically* breaking such short circuit *upon and continuously during the operation of the machine*'—the 2d claim specifically setting forth such means.

"It is conceded by Edison that Gray had fully reduced to a working machine all that he here sets forth and claims, as early as October, 1878.

"Gray made application December 31, 1880. Previous to this, however, in October, 1880, Edison had sworn to and filed another application for this identical device, in which Edward H. Johnson was joined as *joint inventor*.

"Interference was declared between Gray and Edison and Edison and Johnson May 31, 1881.

"Some nine months after Gray's filing and four months after such interference was declared, Edison filed the present application, to wit, September 19, 1881.

"Edison now attempts to go back to 1871–72 and show the reduction to practice of substantially the same invention, and the remains of the device are produced and brought before the Office.

"It seems to have been a device of like character and working on the same principles, and designed for telegraph signaling, for fire alarm, stock quotations, &c.

"He seems to have experimented with it and for the uses for which he designed it, and it may have been satisfactory in operation so far as to demonstrate to him that a device on that plan would be feasible and successful.

"The device that he now presents is so widely different in construction from that old affair, that the conclusion is unavoidable that only the principle is the same—which was old—and the mechanical invention now in contest was not then perfected.

"However, admitting for the sake of the argument, all that can be claimed for it as an operative machine.

"It was tried and exhibited for sale, and no sale or use could be made of it, and it was thrown aside, and its soul went out of it and into some other machine, and after more than ten years it is attempted to shunt the breath of life back into it, and that, too, after it sunk so far into the dust of decay and the darkness of the past, that its progenitor had actually forgotten that it ever existed, when Johnson came to him and proposed begetting between them the same identical device. And it seems that he was only brought to a consciousness of his former conception and giving birth by

raking amongst the debris of his work shop and finding these poor remains, after being incited thereto by the application of Gray and the declaration of such interference.

"We give full credit to all that Mr. Edison now says, but it is too late.

"Another independent, industrious and meritorious inventor came into the field and completed and perfected an invention for which he came to the Office for a patent, all before Edison appeared with any counter claim.

"Edison has done nothing since his abandoned experiments of 1872, except what he did in connection with Johnson, which, instead of aiding his case, militates against it.

"We must affirm the decision of the Examiner of Interferences, and find priority in Gray.

"R. L. B. Clark,
H. H. Bates,
Examiners in Chief."

It will be observed that the Board find in effect, that Edison's "Exhibit Magneto Signal Box" was made in 1872, was put in use to the extent of demonstration of successful operative capacity, that it covers the issue in controversy, but award priority of invention to Gray, who made his invention in 1878, upon the ground that Edison *abandoned* his invention illustrated in his "Signal Box."

It is not overlooked that the Board, in their opinion, assume that "the material matter consists in means for automatically breaking such short circuit" in a particular way, in spite of the fact that the issue is a claim for the combination of four elements, each by implication of law being old, and nothing being new but the combination of them in one machine, and the "means" referred to consequently being of course precisely as important, and no more important, than any other element.

Neither is it overlooked that the same opinion determines *ex cathedra*, without a particle of proof, that the "principle" of Edison's "Signal Box" "is old;" and that Edison's "Sig-

nal box" differs so widely in construction from the devices shown in the various contestant applications that "the conclusion is unavoidable that only the principle is the same," since it is a matter of no consequence how great the difference is so long as each embraces the issue, which is not disputed.

The case, then, turns upon the question of abandonment as affecting—

1. A judgment of priority of invention in an interference.
2. The right of inventor to a patent.

I.

Priority of Invention.

The statute law with regard to interferences in the Patent Office had its beginning in the act of 1793, Sec. 9, where the rights of interfering applicants was submitted to arbitration, and there was no description of what the rights should include.

This statute remained unchanged until the act of 1836, Sec. 8, when the Commissioner of Patents was authorized to hear interferences "on the question of priority of right or invention," and "to determine which or whether either of the applicants is entitled to a patent as prayed for."

This statute remained unchanged until the act of 1870, Sec. 42, which eliminated "the question of priority of right," and retained that of, "priority of invention;" and instead of authorizing the Commissioner "to determine which or whether either of the applicants is entitled to a patent as prayed for," "the Commissioner *may* issue a patent to the party who shall be adjudged the prior inventor."

Here is exhibited a gradual growth of interferences from an arbitration voluntarily entered into by the contestants to determine conflicting rights, to an examination by the Commissioner of Patents, without the consent of the contestants, first, upon priority of right and of invention, with a discretionary power over the issue of a patent to either or neither contestant, then upon priority of invention alone, with a right to the patent on the part of the prevailing party, unless some lawful reason to the contrary should appear. Under the statute the Commissioner may award priority of invention to a contestant, and remit the question of the grant of a patent to another and different examination. It will be noticed that the law makes no provision for the issue of a patent to the unsuccessful party in an interference.

The present statute, Sec. 4904, is a copy of Sec. 42 of the act of 1870.

It is urged, then, that the Board of Examiners in Chief, in an interference proceeding, has no authority of law to determine any question, except that of priority of invention alone, or the simple fact which of the contestants was the *first* to make the invention, and all questions which relate to lawful reasons for the denial of a patent, as, for instance, that of abandonment, are to be settled by the Commissioner with the successful party as an applicant for a patent, and not as a contestant for an award of priority of invention. And the Rules of Practice (rule 120) precisely limit the Board of Examiners in this respect.

II.

What Constitutes Invention,

priority of which is to be determined, must be settled by the Statute, section 4886, which describes it as "any new and useful art, machine, manufacture or composition of matter," * * * "not known or used by others in this country, and not patented or described in this or any foreign country, before his invention or discovery thereof." * * *

The other provisions of this section do not touch the quality of invention, but give the grounds upon which a patent must be denied to the first inventor as an applicant, viz.: public use or sale more than two years before application, and abandonment of the invention.

These bars above referred to to the grant of a patent, relate however only to the first inventor, and give no right to a patent to a subsequent inventor, since, if the bars exist against the first inventor, his invention inures to the public, and no person is entitled to a patent.

The great error of the Board was in determining that a subsequent inventor was the prior inventor, if the party who made the invention first had abandoned it.

It is urged, then, that the Board was in error in determining that Gray was the prior inventor to Edison, who had made the invention six years before Gray, because Edison had abandoned his invention.

III.

As a matter of law and of fact, Edison did not abandon his invention.

The first appearance of the bar of abandonment is in the act of 1870, Sec. 24, which is now the present statute, Sec. 4886, which provided that abandonment of the invention is a bar to a patent, *where the abandonment is proved.*

It is well settled that the law does not favor the bar of abandonment, but requires conclusive proof of it.

The evidence about the supposed abandonment all comes from Mr. Edison and his witnesses, and is substantially this:

The instrument "Signal Box" was made in the summer of 1872. Some of the parts have been mislaid. (f. 35.)

The signal box was taken to New York and set up in the relay room of the Gold and Stock Telegraph Company and put in operation * * * with a call bell, and worked two days, (f. 43, 44;) it operated perfectly, (f. 47;) this was in the fall of 1872. (f. 48.)

Did not intend to apply for a patent on it, because there was no field for its use; if there had been such a field should have applied for a patent. (f. 49, 50.) Kruessi saw this "Signal Box" complete first in 1873 and since. (f. 108.) Ott saw it complete first in 1873, and since, (f. 116,) as late as 1879. (f. 121.) Force has seen it laying around Edison's

establishment for the last five or six years. (f. 126.) Wurth saw it before 1876, and in the summer of 1876 withdrew the permanent magnets for other experimented work. (f. 144.) The "Signal Box" seemed complete then. (f. 145.) Murray took the signal box to New York in 1873, believes, as far as he knows, that the box was laid aside and abandoned at that time. (f. 178, 180.) Left Mr. Edison in 1875. (f. 177.)

It does not appear that these magnets were withdrawn by Wurth with the knowledge or consent of Mr. Edison.

Took up the invention again in the summer of 1879 (f. 50), as soon as there was any demand for magneto calls (f. 64); informed E. H. Johnson about it in 1880 (f. 163), and together they made the invention described in patent 238,098, dated February 2, 1881 (f. 162).

This is all of the evidence touching abandonment.

Mere delay in applying for patent is not abandonment.

Kelleher *v.* Darling, 14 O. G., 673.

Russell and Erwin *v.* Mallory, 5 Fish., 632.

And delays do not affect the inventor's rights until another party appears in the field with the same invention.

Carr *v.* Smith, 5 O. G., 30.

Hockhausen *v.* Weston, 18 O. G., 557.

IV.

The authority of the Commissioner in granting patents is limited by the statute, and he can grant a patent only to the first inventor.

The duty of the courts is to uphold patents as valid grants, if possible.

The courts, therefore, apply general rules of law in suits upon patents for their infringement, and refuse to allow patents to be disturbed by proof of incomplete, unsuccessful, experimented or abandoned *machines* which exhibit an invention like that of the patent in suit, and they give no consideration whatever to a prior invention not put in material form.

The Commissioner of Patents, however, is bound by the Statute and is authorized to consider only the *invention*,

Brief
Edison vs Gray

whether or not it is put in material form; and if it has been "known or used by others in this country," before (Gray's) invention or discovery thereof, he cannot grant Gray a patent or award him priority of invention.

The question of abandonment, so far as it relates to Mr. Edison, is not whether the "Signal Box" was abandoned or broken up, but whether the invention displayed in the "Signal Box" is proved to have been abandoned.

V.

Conclusion.

1. If Edison was the first to make the invention the Commissioner has no authority of law to award priority of invention to a later inventor.

2. If Edison abandoned the invention his invention goes to the public and not to a later inventor.

3. The question of abandonment cannot be settled in an interference proceeding between contestants, but can only be settled with the applicant as such, with the full right to the various kinds of appeals given to an applicant and denied to a contestant.

4. As a matter of fact, the abandonment by Edison is not proved.

5. Edison should have an award of priority of invention, and his application remitted to the Examiner of the class, for proper proceedings there upon the question of abandonment.

Geo. W. Dyer,
For Edison.

Washington, *May* 10, 1883.

Edison v. Maxim v. Swan (1883)

This pamphlet contains a 13-page brief filed on behalf of Edison by D. H. Driscoll of the law firm of Dyer & Seely, probably in 1883. It is entitled "Some Errors in the Brief filed on behalf of Swan" and quotes from that brief and from testimony on behalf of Edison. The case concerns a patent interference relating to electric lighting.

621,3269
(1883)

Mr. Thos. A. Edison

Found in 1890 Correspondence
Dyer & Seely Box.

C. G. Burgoyne's Printing Business, 146-150 Centre St., N. Y.

United States Patent Office.

THOMAS A. EDISON vs. HIRAM S. MAXIM vs. JOSEPH W. SWAN.	Interference. Electric Lamps. No. 8195.

Some Errors in the Brief filed on behalf of Swan.

In accordance with permission granted by the Honorable Examiner of Interferences at the oral argument of this case, errors occurring in Swan's brief, of statement and citation, are noted below.

No attempt has been made to answer the arguments of the brief, except where they have no foundation in the record or are based on a misreading of the testimony, it being understood that the permission accorded extended only to pointing out errors.

The statement made (p. 4) that Edison filed his amended statement so that it would "conform to and support his testimony," is erroneous. At the commencement of the taking of Edison's testimony notice

was given that the amended statement would be filed (E. R., fol. 27).

On page 8, next to last paragraph, it is stated that Edison did not *remember* what material was used in 1877, citing fol. 913, E. R., in support of the statement. An examination of the testimony at that folio will show that there is no ground for the statement. Edison said the material did not impress him one way or the other. He did not say he didn't *remember* what the materials were. On the contrary, at folio 903, E. R., he says of the 1877 carbons that they were paper carbons, some of them in the loop form, and that there might have been six or eight of them.

Beginning at page 9, Swan's Brief claims that a "glaring contradiction" exists between Edison's and Batchelor's testimony; that Edison "flatly contradicts himself," and that his memory is unreliable.

No better foundation for these assertions exist than a misreading of the testimony in the case.

The "glaring contradiction," it is asserted, arises from Edison's alleged testimony that the 1877 filaments were carbonized in tubes—Batchelor, it being alleged, testifying that the same filaments were cut from sheets already carbonized.

An examination of folio 920 of Edison's Record shows that Edison did not testify as is alleged in the brief. What he did say was, "The paper was rolled up *like* a tube and then carbonized." So that to support this "glaring contradiction" the purport of the testimony is changed.

Admitting, however, for the sake of the argument, that Edison did testify as alleged, even then Swan's counsel is in error when the comparison of Edison's and Batchelor's testimony is made which results to their minds in this glaring contradiction.

An examination of the Edison Record preceding folio 920, shows clearly that Edison, when he said the filaments were rolled up like a tube, was testifying regarding filaments of 1878.

When Batchelor testifies that filaments were cut from already carbonized sheets, he has reference to the filaments of 1877 (Swan's Exhibit Batchelor Deposition, fols. 676-685 inc.).

Nothing can be clearer from the testimony of Messrs. Edison and Batchelor than that in 1877 flat strips of carbonized paper were used as filaments.

In 1878 both of these witnesses are in harmony regarding the use of flat strips bent into tubular form.

Edison, fol. 920 E. R.
Batchelor, fol. 599, Swan's Exhibit Batchelor Deposit.

Batchelor says of the 1878 carbons: "The best method I found of making these corbons was to coat tissue paper or very thin paper with a mixture of tar and lamp black, and then *roll them up on a flat plate very tightly.*" It thus appears clearly that the "glaring contraction" alleged, has no existence.

Swan's counsel, pursuing his erroneous assumption, asks "how could a straight strip be first bent and then carbonized in a tube?" and asserts, "There is no proof that this can be done."

As Edison did not testify that a straight strip was bent and carbonized in a tube the inquiry quoted becomes immaterial, and whether there is or is not proof in ~~the record~~ becomes likewise immaterial.

But there is testimony tending to prove that it can be done S.B. Mott (fol 835-6-7-8-9. SR.)

Pursuing further the original erroneous assumption, that Edison testified that the 1877 carbons were bent and carbonized in a tube, Swan's counsel points out the "flat contradiction."

It appearing that Swan's counsel was mistaken as to Edison's testimony regarding the 1877 filaments the alleged flat contradiction itself falls flat.

We fail to perceive the contradiction alleged on page 11, second paragraph to exist between Edison and Batchelor's testimony. It may well be that Batchelor whose time in 1877 "was not wholly devoted to experimenting on electric lighting" (fol. 680, Swan's Exhibit

Batchelor Deposition) forgot an experiment which Edison remembered. But such failure of memory does not constitute a contradiction.

At page 14, second paragraph, it is stated that "Herrick broke many of them (lamps) to economize platinum clamps; he found all were carbons cut in the horse-shoe form" citing fols. 1010 to 1013 S. R. An examination of the testimony at the folios cited will show that this statement is at variance with the testimony given. Herrick testifies that there were other construction of lamps in the case at the time referred to.

On pages 21, 22 and 23, an argument is made to show that the natural way for Edison to prepare carbon filaments from straight strips of paper, would be to follow the method employed when carbonizing thread, it being asserted that Edison did not follow this natural method, but adopted "such a difficult way of carbonizing that within a day or two," it was discarded by reason of its difficulty.

It is admitted for Edison, that the most natural way to carbonize strips of paper would be to carbonize them as thread had been carbonized. It is asserted on behalf of Edison, that this was the way the strips of paper were carbonized. Swan's assertion that this was not done is based on a misreading of the record, combined with an assumption of probabilities for which there is no warrant in the record.

The brief states: "It is admitted by Edison's witnesses that one way to carbonize thread was to do it in a mold."

Citing:

Batchelor E. R., fol. 586.
Upton E. R., fol. 279-9.
Sawyer-Man Record, Herald, 4th Col.

Examing these citations it will be found that Batchelor says nothing about thread at the folio cited. He does state that paper carbons, of parchment paper vulcanized fiber, and many other materials were made

by cutting straight, bending into loop form and "fixed in that position, sometimes by tying them to a piece of carbon having that shape. At other times by placing them when bent, into grooves cut into plates of carbon and nickle, and held in that position during carbonization." Being the way thread was carbonized according to the testimony and the assertion of Swan's counsel.

Swan's counsel evidently confuses the forms or blocks to which the thread and straight cut filaments of paper were tied, with the molds or boxes, in which the forms were placed during carbonization.

Exhibits J and K (the small blocks of carbon), show the forms to which the paper strips were tied during carbonization (force E. R., fol. 434, *et seq*).

Van Cleve (fol. 1349, E. R). makes it clear that these forms of carbon were themselves placed in molds and then carbonized. He says: "The cardboard was cut straight, the two ends of cardboard was fastened on a small block of gas retort carbon by tying with a thread across the cardboard, holding it in place at the turned end * * * then they were placed in forms or boxes covered with pulverized charcoal or fine carbon, after which the top was placed on the box, screwed down with bolts, placed in what was called a preliminary furnace, brought up with a gradual heat to a dull red to expel all gases, after which it was placed in a retort furnace and heated to a white heat, when the carbon was considered complete."

S. D. Mott (fol. 728 S. R.), testifies to the same effect.

"210 x-Q. Did they not at this time also tie the thread to blocks of carbon after bending it into loop or circular form and carbonize it in that position?

A. To prevent the thread from wrinkling up and becoming ill-shaped the loop was fastened in the mold to keep it in place."

Upton does testify, however (fol. 279, E. R.), that the form of gas retort carbon he recollects had a narrow groove cut in it and "In this groove whatever straight filament that was wished to be carbonized could be placed and carbonized," and (fol. 94 E. R.), these forms were "packed in charcoal in an iron case."

The "Herald" article cited at the fourth column says nothing about thread. It refers to the flat horseshoe carbon, which having been cut to form, needed not the aid of gas retort carbon forms, but were placed themselves directly in the molds or flasks.

While the statement that Edison's witnesses admit that one way to carbonize thread was to do it in a mold is, strictly speaking, true, it should be borne in mind that within the mold were the forms like J and K.

Taking for granted that thread was carbonized in molds—but losing sight of the exact method followed—Swan's brief refers to the mold used for carbonizing paper in 1876, and then asserts "This mold was probably the one used for carbonizing thread and afterwards paper."

Citing,

S. D. Mott, S. R., fols. 735, 970.
Flammer, S. R., 2246.
Force, E. R., 448.

An examination of the testimony cited fails to show a scintilla of evidence to support the assertion that the 1876 mold was the one used in 1879, or even that it was probably used.

On the contrary, Swan's witness, S. D. Mott, at fol. 732, says that new molds were made for carbonizing the horseshoe paper lamp, and admits (same fol.) that molds were "changed to suit the requirements of the materials to be used as carbons for lamps."

Proceeding on the false assumption that thread was carbonized in molds, without forms, Swan's brief asserts (p. 22), "It would apparently be impossible to carbonize a straight piece of paper in such a mold; the paper filament would have to stand on edge." This assertion is shown to be untrue by considering that Edison provided forms, to be placed within the molds, for retaining the paper filament in the desired shape, and supporting it during carbonization and, as Mott says, changed the molds to suit the materials.

It is asserted (p. 23), "Besides this, if the paper carbons were made from straight strips of paper, then bent tissue paper could not be placed over it; in fact, only one strip could be carbonized at a time."

Citing,

Herrick, S. R., 1154.

Herrick does not testify that "only one strip could be carbonized at a time," nor does he give any ground for such an assertion. On the contrary, his testimony is confirmatory of Edison's assertion that a form was used in carbonizing paper cut from a straight strip. Herrick states: "A piece of paper cut straight and bent into the form of a loop would require a mold and ligature to keep it in shape." * * *

There is no reason why several filaments of paper cut from a straight strip bent and tied to a form could not be placed in the same mold or box, and, if desirable tissue paper could be placed between them.

Truly, as Swan's brief says, "It would surprise any one who knew how they (Edison's force) had been carbonizing thread, to learn that when they first tried paper they did not carbonize it in the forms they were using for thread and in the same easy way they carbonized thread."

At pages 24 and 25 it is asserted that Edison's great discovery was the horseshoe paper carbon. The word horseshoe is enclosed in quotation marks, and thereby we infer that the flat cut paper horseshoe is referred to. If so, the reference is clearly an erroneous one. Mr. Edison testifies (fol. 791 E. R.):

"x-Q. 142. You regarded the paper carbon as an important thing at the time you were experimenting with it in 1878, 1879 and 1880, did you not?

"A. I regarded the use of the filament of carbon in 1878 and 1880 as a very important invention, but regarded the particular material of smaller importance to the broad patent for a filament of carbon for an incandescent conductor."

Edison, it is admitted in Swan's brief, had the loop or horseshoe form of thread carbon before he had

the paper horseshoe; therefore, the material of the filament being deemed of small importance, if the horseshoe form of the carbon was entitled to be called a great discovery, properly the thread carbon should receive it. It certainly cannot with truth be claimed that the flat cut paper horseshoe is entitled to the claim in the sense Swan's brief used the term of Edison's "great discovery" (see pages 2 to 6 Edison's brief), as it was simply a modification of the thread loop.

S. D. Mott (fol. 747 S. R.) testifies:

"The horseshoe form of cutting was a modification. I should simply call it a modification of the thread loop. * * *"

At several places throughout Swan's brief (notably pages 28, 30 and 51) the testimony of Messrs. Batchelor and Edison in the Sawyer-Man interference is referred to to support the statement that in that interference it was testified that only *one* lamp was made containing a filament or carbon made by cutting a straight strip of paper bending it into loop form and carbonizing while in that form. And that testimony is contrasted with the same witnesses' testimony in the case at bar with the object of showing a contradiction.

It is an error to state that the testimony in the Sawyer-Man interference relates to only one lamp.

An examination of the testimony at the folios cited in Swan's brief (p. 28) will show this clearly.

It will be found that what is stated is that the *first* lamp—not only one lamp—was made at a certain time and that "within a day or two" or "within a day or so" lamps were made having the flat cut horseshoe loop.

What is meant by "within a day or so" appears in Batchelor's testimony. He says (fol. 624, Swan's Exhibit Batchelor Deposition) that the first lamp was made about October 22d, 1879; that "Within a day or so" of this he cut a flat loop in the horseshoe form and "immediately after this made a steel mold in which these loops could be cut quickly" (fol. 622). This steel mold was made about the latter end of November,

1879 (Upton, fol. 103, E. R), the date being fixed by reference to Mr. Batchelor's note-book, where under date of November 28, 1879, with three signatures on the page, a drawing of this clamp or form is found (Upton, fol. 180, E. R.). "Within a day or so" and "immediately after this," therefore, covers a space of about a month, and it cannot with truth be said that only *one* lamp was made this time. On the contrary Upton says (fol. 98, E. R.): "I remember distinctly that for some time, two weeks, I think, we were experimenting with paper cut in this form [first issue] and that we were all working very hard in the line of experimenting of which this forms part."

Upton further says (fol. 237, E. R.) that: "By referring to records I find that lamp 43 is mentioned as 'made of card cut from new model and set in new clamp, steel some as above'; I find this over date of November 17, 1879, and in the handwriting of Mr. Batchelor and signed by him."

"x-Q. 204. Do you know what is meant by 'cut from new model'?

"A. To the best of my recollection it means cut in the same manner as shown on the bottom of Exhibit C."

The bottom figure of Exhibit C is under date of Nov. 11, 1879, and this being the new model, what was done between Oct. 22, the date fixed by Batchelor as the date of the production of the carbon of the first issue, and Nov. 11, must have been different from the new model. It is testified that the carbons then produced were identical with the carbon of the first issue.

In this connection attention is called to the erroneous statement made in the note printed in small type page 51).

As a matter of fact the testimony of Edison and Batchelor was given before the declaration of interference in the case at bar. This declaration is dated October 1st, 1881—Edison's deposition was commenced June 11th, 1881, and Batchelor's July 7, 1881, nearly

three months *before* the declaration of interference instead of six weeks *after* as alleged.

Beginning at page 39 and running to and including page 42 an argument based upon probabilities, erroneous in themselves, is made use of to show that the carbons represented on Exhibits A, B and C were unsuccessful.

It is stated, page 42, "These three Exhibits A, B and C, show that whatever was done in the carbonization of loops was done by electricity in vacuo."

No citation of the record is made in support of this assertion, and elsewhere in the brief carbonization in vacuo is spoken of only as *probably* having taken place with reference to the carbons of Exhibits A, B and C.

As a matter of fact carbonization in vacuo was not attempted until many months after the carbons of Exhibits A, B and C had been made.

Charles P. Mott testifies (fol. 383, S. R.):

"589 x-Q. Do you remember in the month of March, 1880, of Mr. Batchelor making experiments in carbonizing in vacuo?

"A. An apparatus for that purpose was made in the latter part of March, 1880, and experiments made with the apparatus in the early part of April."

Exhibit T, showing the apparatus for carbonizing in vacuo, bears date March 29, 1880.

It is, therefore, absurd to assume, as even probably, that carbons were carbonized in vacuo in November, 1879, when the first record of a carbonizing apparatus operating in vacuo occurs in March of the next year, and Swan's witness' recollection accords with the record. More especially is the absurdity of such an assumption ~~improbable~~ apparent when it is considered that Edison was unsuccessful in carbonizing in vacuo, and to warrant the assumption at all one would have to suppose that Edison persisted from November to April in carbonizing unsuccessfully.

Attempt is made to show that the carbons illustrated

in Exhibits A, B and C were unsuccessful for other reasons besides the erronous one that they were carbonized in vacuo.

Of No. 37 it is stated, page 40, that it was unsuccessful and was never placed in a lamp at all.

And of No. 38 it is stated that also seems to have been unsuccessful, and that it was evidently not sealed off into a lamp.

These statements are erroneous.

Of No. 37, Upton says (fol. 324, E. R.) that it "was an hour incandescent at one time," and of No. 38 he says (fol. 325, E. R.), "was measured for resistance."

One of these carbons (No. 37) is recorded as having "burnt on the pump from an arc," and the other as having "busted on pump." These statements we presume Swan's brief takes for the foundation for the assertion that they were never placed in a lamp at all.

But this is an error, as Upton testifies (fol. 382 E. R.), of No. 38, which is the one recorded as having "busted on pump:

"Was this carbon tested in the receiver of an air pump, or was it sealed in a lamp globe?

"A. It was sealed in a lamp globe."

No. 39 Swan's brief attempts to overthrow by entirely disregarding the testimony. It is stated in the record of this carbon that there was a "small arc at point of contact," and below this statement, after times of burning have been given, it is stated "no arc." Upon this Swan's brief asserts that the lamp must have been destroyed at once, citing Edison, E. R. 1529-30, alleging that when an arc is formed the lamp at once goes to pieces.

Small arcs only "tend to destroy the lamp" (fol. 89 Swan's Exhibit Edison's deposition) * * * "a bad contact between the carbons and the clamp would necessarily follow, accompanied by *small arcs, which would gradually increase and ultimately destroy the contact*" (same Exhibit, fol. 141).

Exhibit M contains the record of the test of lamp No. 39. For the first time this exhibit is alleged, by Swan's brief, to contain the record of two lamps. No.

39 at the top, which it is alleged was destroyed at once, and another lamp at the bottom of the exhibit, which Swan's brief admits "is the one over which occurred the great excitement." Regarding this lamp said to be recorded at the bottom of Exhibit M, Swan's brief states that it "is proved beyond all question to have been the one cut out in horseshoe shape." No citations are given to testimony in the record to support this assertion. Nor can any be given. The assertion is absolutely erroneous.

Exhibit M contains the record of a single lamp, No. 39. No one ever questioned this until Swan's brief appeared. The evidence is so clear on this point that further discussion would be useless. (See Upton, fol. 324 *et seq.*, fol. 360 *et seq.*, and fol. 394 *et seq.*, E. R.)

Of lamp No. 40, which is recorded as having been "made for test," it is asserted (p. 41) that it is probable that "test" referred to testing the connections. No citations from the testimony are given to support this assertion.

What a test lamp is appears from the testimony of S. D. Mott (fol.).

It is asserted (p. 43) that "Edison was not himself the inventor of the first issue of this interference." The main ground for this assertion seems to be that Batchelor made the experiments and kept the records, and page 46, that "there is no proof that he, Batchelor, received any assistance in these experiments, either by way of suggestion, order or manual aid or skill." This statement is erroneous.

Batchelor testifies (fol. 1467, E. R.): "I was in the best position to know all that was done (at Menlo Park), as I was in continual consultation with Edison *and daily getting his ideas* and directing the experiments."

See also fol. 619 *et seq.*, fol. 647–663 Swan's Exhibit Batchelor's Deposition, and fol. 566, same Exhibit, where Batchelor says:

"I have been assistant to Mr. Edison for nearly

eleven years. My occupation has been entirely during the last eight or nine years *the receiving of ideas and sketches and afterwards carrying them out;* making the necessary instruments myself or with any help that I required. I have had general charge of all of Mr. Edison's experiments during that time under himself."

Monce vs. Adams, cited in Swan's brief, has been practically overruled by the case of Allen vs. Moody vs. Gilman, C. D., 1872, page 204.

Respectfully submitted,

D. H. Driscoll,
Dyer & Seely,
For Edison.

Edison v. Sprague (1885)

This 38-page pamphlet contains testimony given by Edison in November 1885 and by John F. Ott in August 1888 in a patent interference involving Edison and John Toby Sprague. Technical notes and drawings by Edison and two caveats (preliminary patent applications) for electric meters, filed by Edison in September 1881, also appear in the printed record as exhibits. Included in the testimony by Edison and Ott are discussions of their work on electric meters between 1878 and 1881.

IN THE UNITED STATES PATENT OFFICE.

EDISON *vs.* SPRAGUE.	***INTERFERENCE:*** ELECTRICAL METERS.

TESTIMONY IN BEHALF OF EDISON.

RICHARD N. DYER,
Attorney for Edison.

JOHN C. TOMLINSON,
Of Counsel.

BURGOYNE QUICK PRINTING CO., COR. WALKER AND CENTRE STS., N. Y.

INDEX.

1

In the U.S. Patent Office. 2

EDISON vs. SPRAGUE.	}	Interference. Electrical Meters.

To MESSRS. BETTS, ATTERBURY & BETTS : 3

Take notice that on Friday, November 13th, 1885, at 10 o'clock A. M. at No. 65 Fifth avenue, New York City, I shall proceed to take the testimony of Thomas A. Edison, Charles Batchelor, Francis R. Upton, John Kruesi, Martin Force, John Ott and others, as witnesses in behalf of Edison, and shall continue the examination from day to day until completed.

You are invited to be present and cross-examine.

RICH'D N. DYER, 4
Atty. for Edison.

5

IN THE U. S. PATENT OFFICE.

EDISON vs. SPRAGUE.	In Interference. Electrical Meters.

6

Preliminary Statement of Thomas A. Edison.

STATE OF NEW YORK, County of New York, } SS.:

7

THOMAS A. EDISON, being duly sworn, deposes and says, that he is a party to the above-entitled interference; that he conceived the invention in controversy in the fall of 1878, and at that time made sketches and experiments and disclosed the invention to others; that he tried a number of fundamental experiments at different times subsequent to said date, involving the principles of said invention; that said invention is embodied in sketches made in August, 1881, and is de-

8 scribed in his caveat filed October 4th, 1881.

THOMAS A. EDISON.

Sworn to and subscribed before me this 15th day of April, 1883. }

WM. H. MEADOWCROFT,
[SEAL.] Notary Public,
New York County.

IN THE U. S. PATENT OFFICE. 9

EDISON,
Application filed Sept. 13, 1882,
AGAINST
SPRAGUE,
Application filed March 7, 1882. 10

INTERFERENCE ELECTRICAL METERS.

Testimony taken in behalf of Thomas A. Edison pursuant to notice hereto annexed at No. 65 Fifth avenue, New York City, the 17th day of November, 1885.

PRESENT: 11

J. E. HINDON HYDE, counsel for Sprague.
JOHN C. TOMLINSON and RICHARD N. DYER, counsel for Edison.

THOMAS A. EDISON, being duly sworn, deposes and says, in answer to questions proposed by JOHN C. TOMLINSON, counsel for Edison, as follows:

1 Q. What is your name, age, residence and occupation? 12

A. Thomas A. Edison; residence, New York; age, 38; occupation, inventor.

2 Q. The issues in this interference have been defined by the Patent Office as follows:

FIRST. The combination with the electrodes of an electrolytic cell, of a rotating body forming part of the circuit between them, and caused to rotate by displacement of its centre of gravity due to the deposition and removal of metal.

SECOND. In an electrolytic measuring apparatus, the

13 combination with the polar plates of an induced electrode capable of rotation in consequence of displacement of its centre of gravity due to the deposition and removal of metal and a registering apparatus connected therewith. When first did you construct apparatus embodying these issues?

> Objected to if intended to contradict or vary the allegations contained in the preliminary
> 14 statement in this case by Thomas A. Edison, and notice is given that a motion will be made to strike out any testimony which may be given by this witness having such a tendency.

A. In January or February, 1879.

3 Q. I now hand you book No. 206 and call your attention to page 41 of that book, who made the sketch upon that page and what is it?

A. I made the sketch; it is a rotating electrode in which copper is deposited on one side of the cylinder
15 and taken off of the other side by electrolysis, thus producing rotation. A recording apparatus connected with the cylinder records the rotation, the number of revolutions.

4 Q. When was this sketch made?

> Same objection as to question 2.

A. April 3d, 1881.

5 Q. In whose handwriting is the description contained on that page?

16 A. The description is in my handwriting. It is initialed by myself and J. F. Ott, one of my assistants.

6 Q. In whose handwriting is the date April 3, 1881?

A. Mine.

7 Q. What is this book No. 206?

A. One of my laboratory note-books.

8 Q. Does the meter, shown and described on this page, embody the issues of the interference?

A. Yes.

> Counsel for Edison here offer in evidence page 41 of Edison's laboratory note-book, 206, and 17
> the same is marked Edison's Exhibit No. 1, and the book is offered to counsel for Sprague for cross-examination.

9 Q. How do you account for the fact that this sketch dated April 3, 1881, is not mentioned in your preliminary statement?

A. Because my preliminary statement was made up hastily from memory and I did not examine the records; the examination of my records and apparatus 18
is a question of some days, and I generally make up my preliminary statements entirely from memory.

10 Q. How many of these note-books have you, and where are they usually kept?

A. Three or four hundred; they are kept by the attorney of the Edison Electric Light Company.

11 Q. Where was this book No. 206 found, and when?

A. It was found by the attorney of the Light Company in one of the drawers in my laboratory three days ago. It seems to have been mislaid. 19

> Answer objected to as incompetent, as not the best evidence.

12 Q. Were you present and assisting in the search when this mislaid book was found?

A. I was.

> Counsel for Edison give notice that if the testimony, with respect to the sketch on page 20
> 41 of book 206 offered in evidence, is found to vary from the preliminary statement a motion will be made at the proper time to amend that statement.

13 Q. What is the paper I now hand you?

A. It is the original manuscript of a caveat on meters furnished the attorney of the Edison Electric Light Company to prepare a caveat for the Patent Office. It is dated May 17, 1881.

21 14 Q. Where do you find this date, May 17, 1881?

A. I find it by looking at the last sheet of the document. I also find other dates—August 28th, 1881, September 7th, 1881.

15 Q. In whose handwriting is the body of this paper, and by whom were the sketches made which are attached to it?

A. My handwriting; the sketches were also made by me. There is one sheet, however, in the writing of the attorney of the Edison Electric Light Company. This
22 is the fifteenth sheet, the one just preceding the sketches, there being twenty-one sheets in all.

16 Q. I call your attention to sketch marked Fig. 2, and to the description contained in the body of the paper referring to that sketch; by whom was this sketch made, and when, and by whom was the description written?

Objected to as already answered.

23 A. The sketch was made by myself. The sketch was made August 28th, 1881. The description was also written by myself—September 9th, 1881.

The paper referred to is offered in evidence and marked Edison's Exhibit No. 2.

17 Q. What construction of meter is shown by figure 3 of this paper and described in the body of the paper
24 with reference to this figure?

Objected to as the paper and sketches are the best evidence.

A. It consists of a copper cylinder partially immersed in a cell containing sulphate of copper. The cylinder is on pivots so as to permit of rotation. On opposite sides of the cylinder are copper electrodes in close proximity to the surfaces of the cylinder. The current passing to one electrode takes copper from it and deposits it on one side of the cylinder; it then passes

through the cylinder leaving it on the other side across 25
the sulphate of copper to the electrode. In leaving it takes copper from the cylinder; thus one side of the cylinder becomes heavy while the other side becomes lighter, thus throwing the cylinder continuously out of balance and producing rotation of the cylinder, a counting apparatus being connected to the same records the number of revolutions.

18 Q. Do you consider that the meter shown and described in this paper embodies the issues in this interference?

A. I do. 26

Notice is here given to counsel for Sprague that the caveat filed by Mr. Edison October 4th, 1881, and referred to in the preliminary statement, is a copy of this paper, Edison's Exhibit No. 2, and that the original caveat will be made a part of the record of this interference, and will be referred to at the argument with full privilege
on the part of counsel for Sprague to examine 27
and use such caveat.

Counsel for Sprague replies that the statement thus made is in no way proof of the matters contained therein and will object to any use whatever of said alleged caveat unless the same or a duly authenticated copy thereof is offered in evidence and made a part of the record and supplied for the purposes of cross-examination on the testimony of this witness.

Counsel for Edison state that they will pro- 28
cure certified copy of the caveat and offer it in evidence.

19 Q. What is the apparatus I now hand you?

A. It is the same kind of an apparatus as shown in figure 3 of my caveat, which I have just described, except that amalgamated zinc electrodes and cylinder are used.

Apparatus referred to is offered in evidence and marked Edison's Exhibit No. 3.

29 20 Q. Referring to the apparatus, described by you as embodying the issues in this interference, did you ever put such apparatus in circuit for use in your laboratory?

A. I did.

21 Q. Did you ever disclose the invention of this meter, and, if so, to whom?

A. Yes; Charles Batchelor, John Ott, Martin Force and others.

22 Q. Am I correct in the assumption that the ex-
30 periments upon this meter were generally known to your laboratory assistants?

Objected to as leading.

A. Yes.

23 Q. By whom and for what purpose was the meter Exhibit No. 3 made?

A. I think it was made by my assistant John Ott. It was made to determine the accuracy of the record.
31 All attempts at obtaining accurate records with weak currents when copper electrodes and salts of copper were used in the meters were not very successful, and it was not until some time in December, 1881, that it was ascertained that amalgamated zinc electrodes in solutions of sulphate of zinc would record weak currents accurately.

24 Q. What success did you have with meters having copper electrodes for strong currents?

A. There is no difficulty with any of the meters
32 whether zinc or copper when strong currents are used, the disturbing influences being a small factor to the strength of the current, but with very weak currents the contrary electro motive force, local action and oxidization of the copper electrode produces such a disturbance that with very weak currents, which are necessarily used in electric lighting meters, the record is very unreliable.

25 Q. Referring to your answer to question 20, about when was the apparatus placed in circuit and used?

Same objection as to question 2.

A. The first apparatus embodying the issues in this 33
interference was placed in circuit in my laboratory some time in January or February, 1879.

26 Q. Under whose direction and in accordance with whose instructions was the Meter Exhibit No. 3 made?

A. By my direction and instruction.

Adjourned to November 27th, 10 A. M.

34

Met pursuant to adjournment.

Same counsel as before.

THOMAS A. EDISON.

Adjourned to December 2d, 11 A. M. 35

DECEMBER 2d, 1886.

Met pursuant to adjournment.

Present—Same parties as before. 36

Adjourned to meet subject to the agreement of counsel.

37 IN THE UNITED STATES PATENT OFFICE.

EDISON,
Application filed Sept. 13, 1882,

AGAINST

38 SPRAGUE,
Application filed March 7, 1882.

Interference.
Electrical Meters.

STATE OF NEW YORK,
City and County of New York. } SS. :

I, MORRIS E. STERNE, a Notary Public in and for the City, County and State of New York, do hereby certify that the foregoing deposition of Thomas A. Edison was taken on behalf of Thomas A. Edison in the above-entitled interference in pursuance to the notice hereto
39 annexed, before me, at No. 65 Fifth avenue, in the City of New York, on the 17th day of November, 1885. That said witness was by me duly sworn before the commencement of his testimony; that said testimony was by consent of counsel written out by Nora McCarthy; that J. E. Hindon Hyde, counsel for Sprague, was present during the taking of said testimony; that said testimony was taken at No. 65 Fifth avenue, in the City of New York, and was commenced at 11 o'clock A. M. on the 17th day of November, 1885, and was
40 concluded on the same day, and that I am not connected by blood or marriage with either of said parties or interested directly or indirectly in the matter in controversy.

In testimony whereof, I have hereunto set my hand and affixed my seal of office at New York City this 24th day of September, 1888.

[SEAL.] MORRIS E. STERNE,
Notary Public,
N. Y. Co.
No. 278.

ORANGE, N. J., Aug. 9th, 1888. 41

Met pursuant to agreement.

Present—L. E. CURTIS, ESQ., counsel for Sprague; R. N. DYER, ESQ., counsel for Edison.

JOHN F. OTT, a witness produced on behalf of Edison, being duly sworn, deposeth and says in answer to questions proposed by counsel for Edison:

1 Q. What is your name, age, residence and occupation? 42

A. John F. Ott; age, 38; residence, No. 276 High street, Orange; occupation, superintendent of the laboratory of T. A. Edison.

2 Q. How long have you been connected with Mr. Edison?

A. For the last eighteen years.

3 Q. Were you connected with him during his electric light experiments in 1878, and since that time, and 43
if so, in what capacity?

A. Yes, sir; I was. I was employed in making all sorts of apparatus from pencil sketches for electrical and other work.

4 Q. Did you know of any experiments by Mr. Edison on electric meters employing electrolytic or decomposition cells, and if so, where were these experiments begun?

A. My first recollection of these experiments was in the fall of 1878.

5 Q. I call your attention to page 41 of Mr. Edison's 44
Laboratory Note Book No. 206, which page is marked in evidence as Edison's Exhibit No. 1. Have you ever seen this page before?

A. Yes, sir; I put my initials "J. F. O." on that page as a witness on April 3d, 1881.

6 Q. What is the experiment recorded on that page?

A. It is a meter experiment of Mr. Edison wherein a copper cylinder is immersed in a sulphate of copper solution with a copper plate immersed in the solution

45 on each side of the cylinder and connected in a shunt around a resistance in the circuit. The idea was, that the cylinder would be revolved by displacement of its centre of gravity by the depositing of metal on one side and stripping it from the other side, and this revolution of the cylinder was to be registered by a counter.

7 Q. Was apparatus of this character ever constructed for Mr. Edison, so far as you know?

A. Apparatus working upon the same principle was
46 constructed some time in the year 1880. I think in the latter part of that year. The only essential respect in which that 1880 apparatus differed from the sketch on page 41 of book 206 was that in place of the cylinder a number of copper plates the same as a paddle-wheel were mounted radially upon the shaft. The operation of the apparatus was the same as of this apparatus shown on page 41 of book 206. After the date of the sketch on page 41 other apparatus like this sketch in all respects was made in the year 1881,
47 and still later in 1882, after Mr. Edison had adopted amalgamated zinc plates and sulphate of copper solution for his meter, we made still other apparatus upon this principle.

CROSS-EXAMINATION WAIVED.

Sworn to before me this ninth day of August, A. D. 1888, at Orange, N. J. — JOHN F. OTT.

48

WM. J. KEARNS,
Notary Public, in and for New Jersey.

Counsel for Edison offers in evidence a certified copy of a caveat, filed by Mr. Edison October 4th, 1881, for "Improvement in Electric Meters," and the same is marked "Edison's Exhibit Meter Caveat of October 4, 1881."

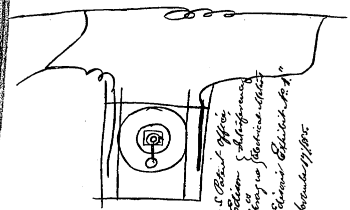
STATE OF NEW JERSEY, } 49
County of Essex, }

I, WILLIAM J. KEARNS, a notary public, within and for the State of New Jersey, do hereby certify that the foregoing deposition of John F. Ott was taken on behalf of Thomas A. Edison, in pursuance of the notice hereto annexed, before me at the laboratory of T. A. Edison, Esq., in Orange, in said County, on the ninth day of August, 1888; that said witness was by me duly sworn before the commencement of his testimony; that the testimony of said witness was 50
written out by myself stenographically, and afterward transcribed in my presence into longhand; that said testimony was taken at Orange aforesaid, and was commenced at 11 o'clock, A. M., on the ninth of August, 1888, and was concluded on the same day; that I am not conneted by blood or marriage with either of said parties, nor interested directly or indirectly in the matter in controversy.

In testimony whereof, I have hereunto set 51
[SEAL.] my hand and affixed my seal of office, at Newark, in said County, this ninth day of August, 1888.

WM. J. KEARNS,
Notary Public.

52



U. S. Patent Office;
Edison vs Sprague Interference Electrical Meters
"Edison's Exhibit No. 1."
November 17/1885.

Copper cylinder revolving in a Sulphate Copper Solution, with a weighted Counter within it so that when cylinder revolves Counter will stand still, deposit of Cu on one side & taken off other

April 3 1881 TAE
J.F.O

Original Caveat.

U. S. PATENT OFFICE. 53

EDISON vs. SPRAGUE.	Interference. Electrical Meters.

"Edison's Exhibit No. 2," Nov. 17, 1885. 54

CAVEAT ON METERS.

The object of this invention is to produce an electric meter capable of measuring in a convenient and economical manner the quantity of electricity passing in an electric circuit.

The invention consists in various devices, many of which I have tried and others which I am now engaged 55
in experimenting upon to ascertain the best kind to meet all the conditions for practical use in my system of electric lighting.

In Fig. 1 is shown a meter which records by the expansion of the air in a closed chamber A, such expansion being due to the heating of a coil of wire carbon or other conductor B placed within such chamber. C is a flexible portion of the chamber working like that of an aneroid barometer or an accordion; the movement of this flexible portion of the chamber serves to 56
give motion to a lever *d*, which actuating a ratchet in the counter *f* serves to count every reciprocation or vibration of the lever *d*. The wire B being in one part of the main circuit M, N, is heated upon the passage of the current, this in its turn expands the air within the chamber; this moves the lever downward when at a certain point it touches the lever K and moves it from the point L to the point G. Now the lever K being connected to one side of the wire in the chamber while the point G is connected to the other side, the contact

57 of the two serves to shunt the current almost entirely
from the wire B, thus allowing it to cool, hence the air
contracts, the lever is drawn upwards and when it
reaches a certain point it disconnects the lever K from
G, breaking the shunt, whereupon the coil B again be-
comes heated and expands the air and the lever makes
another vibration, the minimum current with which the
lever d will make a complete vibration being that due
to placing a single electric lamp across the circuit, the
addition of more lamps will cause the air to expand
58 more quickly, hence the lever d will make a greater
number of vibrations per minute, the number being
proportionate to the number of lamps, each reciproca-
tion counts.

Fig. 2 is a modification, the expansion of the wire A,
forming part of the circuit serving to replace the air
chamber. Preferably this wire is enclosed in a chamber
but the expansion of the air contained therein is not
utilized.

Fig. 3 shows a continuously counting meter upon the
59 copper depositing principle. A is a narrow trough in
which rotates a disc B of copper upon the pivot C. On
its opposite edges are two copper poles or electrodes.
Connected to the resistance h in the main line
K, L by the wires g, f. These electrodes are marked
e, d. When a current passes through the liquid from
the electrode d, it passes from it through the thin
stratum of liquid to the edge of B nearest to it, thence
through the copper disc to the other edge opposite e,
thence through the liquid to e, a portion of the
60 current, of course, passes through the liquid in the
bottom of the trough but this is very small. The
result of the action of the current is to take off
copper from d, adding it to the edge of B, thus
making B heavier on the side towards d, and at the
same time copper is taken off the edge of B opposite e
and deposited upon e, thus lightening the edge of the
disc B opposite e, hence by the copper deposit one
side of B is continually made heavier while the other
edge is made lighter, this causes a continuous rotation
of the disc which, if its shaft be connected with a

counter will give the amount of current passing. Fig. 4, 61
shows an electro-magnet N, which vibrates a lever K
pivoted at m and retracted by the moveable weight L.
On the lower extremity of this lever is a rack f which
engages into a pinion g secured to the shaft e. Upon
the same shaft is a retarding fan H, and also a disc d,
which carries a click or dog B, engaging in a ratchet
wheel placed on another and independent shaft, the
latter shaft being a part of the counter. At every re-
ciprocation or vibration of the lever K the shaft e is
rotated a $\frac{1}{2}$ or $\frac{1}{4}$ turn and then brought back to its orig- 62
inal position; but this reciprocation of the shaft e
causes a rotation of the counter shaft in a constant
direction. R is a lever which is moved by K. When
a current passes through the magnet N the lever K is
attracted when it reaches a certain point in its forward
movement it separates the lever R from the point S
and breaks the circuit of the magnet N, the lever K
falls back and throws R against S, again closing the
circuit, when the same action again takes place, the
number of vibrations of K being, within certain limits, 63
proportionate to the current passing through the mag-
net N, it follows that the counter A will record the
total current passing.

Fig. 5 shows a continuously vibrating pendulum O,
secured at 20 and provided with contact springs 1 and
2, facing contact points Q, P; the point P is connected
by wire 4 to the magnet R while Q is connected to the
magnet S by the wire 5. The other ends of the magnet
are connected together and to the line by the wire N.
The pendulum itself is connected to the other portion 64
of the line by the wire M; thus a derived or
multiple arc circuit serves to work the pendulum,
when the latter in its oscillation has its contact
point come in contact with the point P, a current
passes through the magnet R for an instant, causing it
to attract the pendulum; upon the bob T of the latter
there is secured a piece of soft iron on each side; hence
the pendulum goes towards R; when the spring Z
touches point Q the reverse action takes place and the
magnet S attracts the pendulum; this continues as long

65 as there is current on the main line K L. The pendu-
lum itself serves to vibrate a lever V pivoted at W, and
playing between contact points; the lever and points
serve to open and close the circuit of a magnet A at
each vibration of the pendulum; thus the lever *e* of the
magnet A is vibrated regularly; upon the extremity of
this lever is a pawl *d*, engaging in a ratchet wheel B.
This ratchet has a click *c*, which prevents it going
backward; this ratchet is on the shaft of the counter.
The retractile force on the lever *e* is a stiff spring *f*. If
66 a single lamp is put across the circuit at the ends
marked L, K a current passes through the magnet A
and the lever vibrates, but owing to the stiffness of the
spring if it barely catches one tooth in the ratchet B,
thus advancing the counter shaft very slightly at each
vibration. If now another lamp is put across the main
circuit the current is doubled in A, and as it has more
power the spring *f* bends to a greater extent and the
click *d* carries the ratchet wheel forward two teeth,
and so on until ten lamps are on; when this point is
67 reached a second magnet requiring the current due to
ten lamps to give its first vibration can be put in circuit,
its counting being of a higher value.

In Fig. 6 a copper depositing cell V is put across the
line in multiple arc, but included in circuit with it are
a number of resistances, W, X, Y, Z. These resistances
are cut in and out of circuit by the movement of the
levers of the electro-magnets E, F, G, H, K. The
magnets K and E are so adjusted that the placing of
the first lamp across the mains will allow enough cur-
68 rent to pass to cause the magnets to attract their levers;
the lever of K serves to connect the depositing cell and
resistance in circuit, while the lever of E cuts out R, W,
causing the current passing to be of the proper strength
to deposit the amount of copper in V to represent a
lamp. If now another lamp is placed across the main
circuit it will cause the lever of F to be attracted, cut-
ting out the resistance X and causing double the de-
posit to take place in V, and so on.

In Fig. 7 is shown an electro-magnet. A whole lever
rests upon a large number of springs *i, i, i*, all separated

from each other. When no current energizes the mag- 69
net A a resistance R is divided upon into as many coils
as there are springs and a spring is connected by a wire
and between each coil.

M is a copper depositing cell or electro-motor work-
ing a counter; its current is obtained by a derived or
multiple arc circuit across the main and through the
resistance, R. F is an electro-magnet which, when no
lamps are on, open the meter circuit, thus preventing
recording, but when a lamp is put in, the circuit causes
F to close the meter circuit and the deposit takes 70
place; if now two lamps are put in the lever of A
comes down upon the springs with sufficient force to
close the top and next spring under together, cutting
out of the meter circuit a definite portion of the resist-
ance, R, thus increasing the deposit; if three lamps are
put in, then two more springs are pressed together by
the action of the increased strength of current acting
through A upon the lever B, and so on.

Fig. 8 shows a device which I now use in my regular
meter to close the meter circuit only when a lamp is 71
on, and to open it when no lamps are on, so that the
counter electro-motive force will not cause a redissolv-
ing of the copper deposited by lamps previously on.

Fig. 9 shows an indicating meter where mercury is
used. C is the main containing cell of glass; N a
carbon electrode, *p* is another carbon electrode; *d* is
a tube small at the bottom and wide at the top.

The whole of the cell is filled with a mercurial solu-
tion. When a current passes metallic mercury appears
at P and drops down in the tube *d* as fast as formed 72
and in proportion to the strength of the current by
using an index card, the amount of mercury in the tube
can be read off; by reversing the current this mercury
may be made to disappear, and thus allowing of read-
ing the total current which has passed in a given time.

Fig. 10 shows a balanced beam cell, B, containing a
mercurial solution with the electrodes at the end; the
beam is balanced at F, a pointer, *f*, retracted by a
spring, G, serves to indicate the deflection of the beam
at H. A A are mercury cups, into which wires dip,

73 which lead to the carbon electrodes in the ends of the beam cell; when the current passes mercury is taken by electrolytic action from one end of the beam and deposited at the other, thus causing it to deflect and indicate. It is obvious that continuous counting could be obtained by applying the devices shown in my beam meter, for which I already have a patent.

Fig. 11 shows two dishes; one, F, contains metallic mercury and forms one electrode, while a glass chamber, C, over the open mouth of which is stretched or
74 placed a porous diaphragm; this chamber is also filled with metallic mercury up to the top of the tube, B.

Some mercurial solution is poured over the mercury E to allow of electrolysis; the mercury in C is connected to the main line shunt by a platina wire, X, passing through the chamber, while the mercury E is connected by another wire. When a current passes the total amount of metallic mercury in C is increased, hence it overflows into A, where its amount can be read off.

75 It is obvious that if instead of allowing it to fall in A, it were to fall in buckets arranged at intervals around the rim of a wheel, it would rotate the wheel and each bucket would, when it came around, deliver the mercury back into E to be again carried upwards into *c*, the shaft of the bucket wheel being connected to a counter a continuous counting would take place.

Good-night,

76

T. A. Edison.

September 9, 1881.

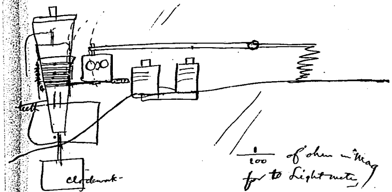
Add—In my regular deposit meter I have used plates of amalgamated zinc in a solution of sulphate of zinc, the zinc being electrically deposited and weighed.

Fig. 12 shows an electro magnet A in the main or consumption circuit. It may instead be in a shunt therefrom. The armature lever B is retracted by spring *a* and carries a counter or a register C, operated

by an exposed cog wheel *b*. Cog wheel *b* engages with 77
the teeth of a variable gear D, which is driven at a uniform speed by clock work E, or other suitable driving mechanism. The gear D is a cylinder having rows of teeth, which vary in number, the number of teeth being regularly diminished from the bottom to the top of the cylinder. If no lamp is in circuit, the wheel *b* will be raised by spring *a* wholly above the teeth of D. If one lamp is turned on, *b* will be drawn down and will be moved by one tooth on D. If two lamps are used, *b*
will be drawn down to next row which has two teeth, 78
and so on for additional lights until the maximum number of lights for which the meter is arranged has been reached.

79

80



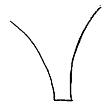
$\frac{1}{100}$ of ohm in Mag for to Light meter

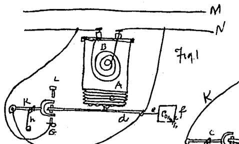
Meter —

May 17 1881 TAE

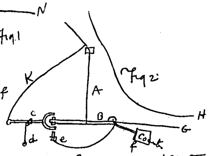
S. D. Mott

Witness

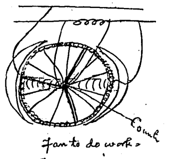




Expansion of air Meter.
Aug 28 1881 TAE



Expansion of wire Meter
Aug 28 1881 TAE



Fan to do work =
gramme ring very
light but large
diameter to obtain leverage
say 10 inches, likely to
weigh over one pound -
field in Multiple arc -

Aug 28 1881 TAE

Meter =

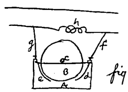


fig 3

also in circuit
Continuous Meter
Aug 28 1881 TAE

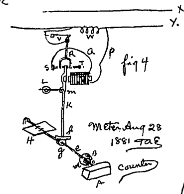


fig 4

Meter Aug 28
1881 TAE
Counter

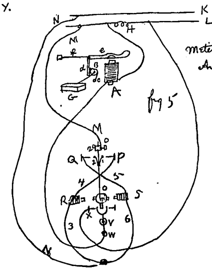


fig 5

Meter
Aug 28 1881
TAE

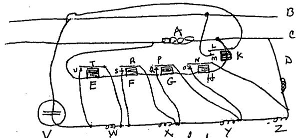


fig 6

Witn Sept 7 1881 TAE

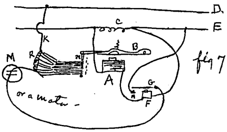
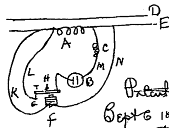


fig 7



~~Patent~~ Caveat

Sept 6 1881

TAE

fig 8

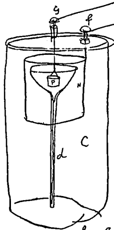


fig 9

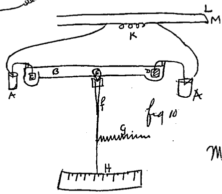


fig 10

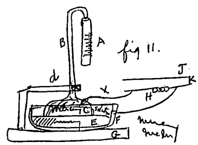


fig 11.

Menlo Sept 10 1881

81

U. S. PATENT OFFICE.

EDISON.

vs.

SPRAGUE 82

"Edison's Exhibit Meter Caveat of October 4, 1881." August 9, 1888.

[2—175.]

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE. 83

To all persons to whom these presents shall come, greeting:

This is to certify that the annexed is a true copy from the files of this office of the petition, specification, oath and drawing, in the matter of the caveat of
THOMAS A. EDISON,

Filed October 4th, 1881.
For improvement in electric meters.

84

In testimony whereof, I, BENTON J. HALL, Commissioner of Patents, have caused the seal of the Patent Office to be affixed this 9th day of August, in the year of our Lord, one thousand eight hundred and eighty-eight and of the Independence of the United States the one hundred and thirteenth.

[SEAL.]

BENTON J. HALL,
Commissioner.

85 No. 1.

The petition of Thomas A. Edison, a citizen of the United States, residing at Menlo Park, in the County of Middlesex and State of New Jersey, represents:

That he has made certain improvements in electric meters, and that he is now engaged in making experiments for the purpose of perfecting the same, preparatory to applying for letters patent therefor.

He therefore prays that the subjoined description of his invention may be filed as a caveat in the confiden-
86 tial archives of the Patent Office.

Thomas A. Edison.

To the Commissioner of Patents:

Be it known, that I, Thomas A. Edison, a citizen of the United States, residing at Menlo Park, in the County of Middlesex and State of New Jersey, having
87 invented certain improvements in electric meters, and desiring further to mature the same file this my caveat therefor, and pray protection of my right until I shall have matured my invention.

The following is a description of my newly invented improvements in electric meters, which is as full, clear and exact as I am able at this time to give, reference being had to the accompanying drawings forming a part hereof.

The object of the invention is to produce an electric
88 meter capable of measuring in a certain, convenient and economical manner the quantity of electrity passing in an electric current.

The object I expect to be able to accomplish in a number of ways, by devices, some of which I have tried and others of which I am now engaged in experimenting upon to ascertain the best form to meet all the conditions of practical use in my system of electric lighting.

In figure 1, is shown a meter which records by the expansion of the air in a closed chamber A; such expansion being due to the heating of a coil of wire,

carbon or other conductor, B, placed within such cham- 89
ber. C is a flexible portion of the chamber working like that of an aneroid barometer or an accordion; the movement of this flexible portion of the chamber serves to give motion to a lever *d*, which actuating a ratchet in the counter *f*, serves to count every reciprocation or vibration of such lever *d*. The wire B being in one part of the main circuit M, N, is heated upon the passage of the current; this in turn expands the air within the chamber; this moves the lever *d* downward, when, at a
certain point, it touches the lever K, and moves it from 90
point L to the point G.

Now, the lever K being connected to one side of the wire in the chamber, while the point G is connected to the other side, the contact of the two serves to shunt the current almost entirely from the wire B, thus allowing it to cool; hence the air contracts, and the lever *d* is drawn upwards; when the lever *d* reaches a certain point it disconnects the lever K from G, breaking the shunt, whereupon the coil B again becomes heated
and expands the air, and the lever *d* makes another 91
vibration.

The minimum current with which the lever *d* will make a complete vibration being that due to placing a single electric lamp across the circuit, the addition of more lamps will cause the air to expand more quickly and the lever *d* to make a greater number of vibrations per minute, the number of vibrations being proportionate to the number of lamps. Each vibration has an effect upon the recording mechanism, the dial or dials
of which may be arranged for any desired system of in- 92
dication.

Figure 2 shows a modification of Figure 1, the expansion of the wire A forming part of the circuit serving to replace the air chamber. This wire is preferably inclosed in a chamber, but the expansion of the air is not utilized.

Figure 3 shows a continuously counting meter upon the depositing cell principle. A, is a narrow trough, in which rotates a disc B of copper upon its axle *c*. On opposite edges of the disc are two copper poles or elec-

93 trodes, connected to the resistance h in the main line K L by the wires g f. These electrodes are marked e d. When a current passes through the liquid from the electrode d it goes through the thin stratum of liquid to the edge of B nearest d; thence through the copper disc to the other edge opposite c, and through the liquid to e. A portion of the current, of course, passes through the liquid in the bottom of the trough, but this is very small.

The result of the action of the current is to take off
94 copper from d, adding it to the edge of B, thus making B heavier on the side towards d, and at the same time copper is taken off the edge of B opposite e, and deposited upon e, thus lightening the edge of the disc B opposite e. Hence by the copper deposit one side of B is continually made heavier, while the other side is made lighter, thus causing a continuous rotation of the disc, which, if its shaft be connected with a counter will give the amount of current passing.

Figure 4 shows an electro-magnet N, which vibrates
95 a lever K, pivoted at m, and retracted by the movable weight L.

On the lower extremity of this lever is a rack f, which engages with a pinion g secured to the shaft e. Upon the same shaft is a retarding fan H, and also a disc d, which carries a pawl B engaging a ratchet wheel placed on another and independent shaft, the latter shaft being a part of the counting or recording mechanism.

At every reciprocation or vibration of the lever K, the shaft e is rotated a half or quarter turn, and is then
96 brought back to the original position, but this reciprocation of the shaft e causes a rotation of the counter shaft in a constant direction. R is a lever which is moved by K. When a current passes through the magnet N, the lever K is attracted. When it reaches a certain point in its forward movement it separates the lever R from the point S, and breaks the circuit of the magnet N. Then the lever K falls back and throws R against S, again closing the circuit, when the same action is repeated. The number of vibrations of K per minute being, within certain limits, proportionate to

the current passing through the magnet N, it follows .7
that the counter A will record the total current passing.

Figure 5 shows a continuously vibrating pendulum O, secured at 20, and provided with contact springs 1 and 2, facing contact points Q P. The point P is connected by wire 4 to the magnet R, while Q is connected to the magnet S by the wire 5. The other ends of the magnets R S are connected together and to the line by the wire N.
The pendulum itself is connected to the other portion 9ε
of the line by the wire M. Thus a derived or multiple arc circuit serves to work the pendulum. When the latter in its oscillation has its contact point come into contact with P, a current passes through the magnet R, for an instant, causing it to attract the pendulum. Upon the bob T of the latter, there is secured a piece of soft iron on each side. The pendulum moves towards R. When the spring 2 touches point Q the reverse action takes place, and the magnet S attracts the pend-
ulum. This continues as long as there is current on 99
the main line K L. The pendulum itself serves to vibrate a lever V, pivoted at W and playing between contact points. The lever and points serve to open and close the circuit of a magnet A at each vibration of the pendulum.

The lever e of the magnet A is vibrated regularly. Upon the extremity of this lever is a pawl d engaging in a ratchet wheel B. This ratchet has a click c which prevents its going backward. The ratchet wheel is on
the counter-shaft. The retractile force on the lever e 100
is a stiff spring f.

If a single lamp is put across the circuit at the ends marked L K, a current passes through the magnet A and the lever e vibrates, but owing to the stiffness of the spring f it barely catches one tooth in the ratchet B, thus advancing the counter-shaft very slightly at each vibration. If, now, another lamp is put across the main circuit, the current is doubled in A, and, as it has more power, the spring f bends to a greater extent and the pawl d carries the ratchet wheel forward two

101 teeth, and so on until ten lamps are on. When this point is reached a second magnet, requiring the current due to ten lamps to give its first vibration, can be put in circuit, its counting being of a higher value.

The ratchet wheel B will of course be provided with fine teeth to give a sensitive movement.

In figure 6, a copper depositing cell V is put across the line in multiple arc, but included in circuit with it are a number of resistances W, X, Y, Z. These resistances are cut in and out of circuit by the movement of
102 the levers of the electro-magnets E, F, G, H, K. The magnets K and E are so adjusted that the placing of the first lamp across the mains will allow enough current to pass to cause the magnets to attract their levers.

The lever of K serves to connect the depositing cell and resistances in circuit, while the lever of E cuts out W, causing the current passing to be of the proper strength to deposit the amount of copper in V to represent a lamp. If, now, another lamp is placed across the main circuit, it will cause the lever of F to be attracted,
103 cutting out the resistances X, and causing double the deposit to take place in V, and so on.

In figure 7 is shown an electro-magnet A, whose lever rests upon a large number of springs *i*, all separated from each other when no current energizes the magnet A. A resistance R is divided into as many coils as there are springs, and a spring is connected by a wire to a point intermediate between each pair of coils. M is a copper depositing cell, or an electro-motor working a counter.

104 Its current is obtained by a derived or multiple arc circuit across the mains and through the resistance R. F is an electro-magnet which, when no lamps are on, opens the meter circuit and prevents recording; but, when a lamp is put on the current causes F to close the meter circuit, and the deposit takes place.

If, now, two lamps are put on, the lever of A comes down upon the springs with sufficient force to close the top and next spring under together, cutting out of the meter circuit a definite portion of the resistance R, and increasing the deposit. If three lamps are put in, then two more springs are pressed together by the action of

the increased strength of current acting through A 105
upon the lever B, and so on.

Figure 8 shows a device which I now use in my regular meter to close the meter circuit only when a lamp is on and to open it when no lamps are on so that the counter electro-motive force will not cause a redissolving of the copper deposited by lamps previously on. A is a depositing cell meter and B the electro-magnet for opening and closing the meter circuit.

Figure 9 shows an indicating meter in which mercury is used. C is the main cell of glass N a carbon 106
electrode. P is another carbon electrode; *d* is a tube, small at the bottom and wide at the top. The whole of the cell C is filled with a mercurial solution.

When a current passes metallic mercury appears at P and drops down into the tube *d* as fast as formed, and in proportion to the strength of the current.

By using an index card the amount of mercury in the tube can be read off. By reversing the current this mercury may be made to disappear, thus allowing of reading the total current which has passed in a given 107
time.

Figure 10 shows a balance beam cell B containing a mercurial solution, and having the electrodes at the ends. The beam is balanced at F.

A pointer *f* retracted by a spring G serves to indicate the deflection of the beam at H. A A are mercury cups, into which wires dip which lead to the carbon electrodes in the ends of the beam cell. When the current passes mercury is taken by electrolytic action from one end of the beam, and deposited at the 108
other end, thus causing it to deflect and indicate.

It is obvious that continuous counting could be obtained by applying the devices shown in my beam meter, for which I already have a patent.

Figure 11 shows two dishes; one, F, contains metallic mercury and forms one electrode, while a glass chamber C, over the open mouth of which is stretched or placed a porous diaphragm, is also filled with mercury up to the top of tube B and forms the other electrode.

109 Some mercurial solution is poured over the mercury E.

To allow of electrolysis the mercury in C is connected to the main line shunt by a platina wire X passing through the chamber, while the mercury E is connected by another wire. When a current passes the total amount of metallic mercury in C is increased. Hence it overflows into A, where its amount can be read off. It is obvious that if, instead of allowing it to fall in A, it were to fall into buckets, arranged at intervals
110 around the rim of a wheel, it would rotate the wheel, and each bucket would, when it comes around deliver the mercury back into E to be again carried upwards into C. The shaft of the bucket wheel being connected to a counter, a continuous counting would take place.

Figure 12 shows an electro-magnet A in the main or consumption circuit. It may instead be in a shunt therefrom.

The armature lever B is retracted by spring *a* and carries a counter or register C, operated by an exposed
111 cogwheel *b*.

Cogwheel *b* engages with the teeth of a variable gear D, which is driven at a uniform rate by clock work E, or other suitable driving mechanism. The gear D is a cylinder having rows of teeth which vary in number, the number of teeth being regularly diminished from the bottom to the top of the cylinder. If no lamp is in circuit the wheel *b* will be raised by spring *a* wholly above the teeth of D. If one lamp is turned on *b* will be drawn down and will be moved by one tooth on D.
112 If two lamps are used *b* will be drawn down to the next row which has two teeth, and so on for additional lights until the maximum number of lights for which the meter is arranged has been reached.

In my regular depositing-cell meter I have used plates of amalgamated zinc in a solution of sulphate of zinc, the zinc being electrically deposited and weighed.

This specification, signed and witnessed this 23d day of September, 1881.

Witnesses: THOS. A. EDISON.

RICH'D. N. DYER,
H. W. SEELEY.

STATE OF NEW YORK, } ss.: 113
County of New York, }

On this 23d day of September, 1881, before the subscriber, a Notary Public in and for said county, personally appeared the within-named Thomas A. Edison, and made solemn oath that he verily believes himself to be the original and first inventor of the within-described Improvement in Electric Meters; that he does not know, and does not believe, that the same were ever before known or used, and that he is a citizen 114
of the United States.

WM. H. MEADOWCROFT,
[L. S.] Notary Public,
New York County.

E. J.
F. C. T.

[ENDORSED:]

Patent Office Serial No. . Thomas A. Edison 115
Caveat. Executed Sept. 23, '81. Filed Oct. 4, '81.
Subject—Electric Meters.

{ U. S. Patent Office, }
{ Oct. 4, 1881. }

Dyer & Wilber, Attorneys.
No. 3049.

116

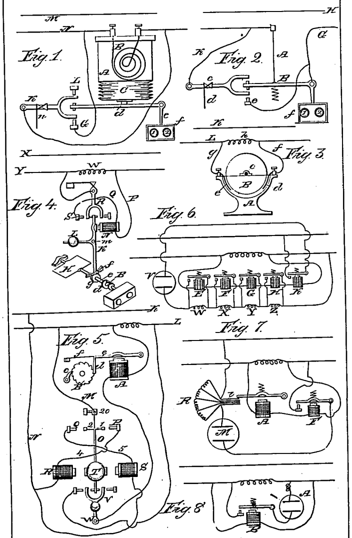
2 Sheets, Sheet 1.

T. A. Edison.

Electric Meter.

Caveat.

Filed Oct. 4, 1881.



2 Sheets Sheet 2.

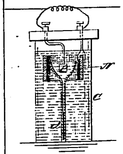
T. A. Edison.

Electric Meter.

Caveat

Filed Oct. 4, 1881

Fig. 9.



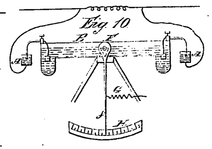


Fig. 10

Fig. 11.

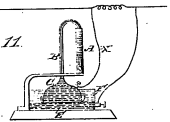
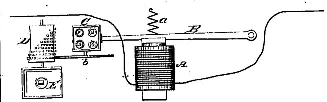


Fig. 12.



Sprague v. Edison (1885)

This 18-page pamphlet contains testimony given by Edison between November 1885 and February 1886 and by Charles Batchelor and John F. Ott in August 1888 in a patent interference involving Edison and John Toby Sprague. A technical drawing by Edison also appears in the printed record as an exhibit. Included in the testimony are discussions of Edison's work on electric meters in 1878.

IN THE UNITED STATES PATENT OFFICE.

SPRAGUE. *vs.* EDISON	***INTERFERENCE:*** ELECTRICAL METERS. (CASE B.)

TESTIMONY IN BEHALF OF EDISON.

RICHARD N. DYER,
Attorney for Edison.

JOHN C. TOMLINSON,
Of Counsel.

BURGOYNE QUICK PRINTING CO., COR. WALKER AND CENTRE STS., N. Y.

INDEX.

1

IN THE U. S. PATENT OFFICE. 2

SPRAGUE vs. EDISON.	Interference. (Case B.) Electrical Meters.

To Messrs. Betts, Atterbury & Betts: 3

Take notice that on Friday, November 13th, 1885, at 10 o'clock, A. M., at No. 65 Fifth avenue, New York City, I shall proceed to take the testimony of Thomas A. Edison, Charles Batchelor, Francis R. Upton, John Kruesi, Martin Force, John Ott and others, as witnesses in behalf of Edison, and shall continue the examination from day to day until completed.

You are invited to attend and cross-examine.

Rich'd N. Dyer, 4
Attorney for Edison.

5

IN THE UNITED STATES PATENT OFFICE.

6 SPRAGUE vs. EDISON.	Interference. Electrical Meters. Case B.

Preliminary Statement of Edison.

STATE OF NEW YORK,
7 County of New York, } ss.:

THOMAS A. EDISON, being duly sworn, deposes and says, in relation to the matters in issue in the above-entitled interference, as follows:

That he conceived the invention in issue as early as October, 1878, and at about the same date disclosed it to others. That he made sketches and models of same in December, 1878, and put the same in actual use early in 1880, and has used the same since.

8 THOS. A. EDISON.

Sworn to and subscribed before me this 15th day of April, 1883. }

WM. H. MEADOWCROFT,
[SEAL.] Notary Public,
New York County.

IN THE U. S. PATENT OFFICE. 9

SPRAGUE,
Application filed May 9, 1881,
AGAINST
EDISON,
Application filed January 31, 1881. 10

INTERFERENCE ELECTRICAL METERS.—CASE B.

Testimony taken in behalf of Thomas A. Edison pursuant to notice hereto annexed, at No. 65 Fifth avenue, New York City, the 17th day of November, 1885.

PRESENT:

J. E. HINDON HYDE, Counsel for Sprague. 11
JOHN C. TOMLINSON and RICHARD N. DYER, Counsel for Edison.

THOMAS A. EDISON, being duly sworn, deposes and says in answer to questions proposed by John C. Tomlinson, counsel for Edison, as follows:

1 Q. What is your name, age, residence and occupation?

A. Thomas A. Edison; residence, New York; age, 38; occupation, inventor. 12

2 Q. Please state generally the experiments upon which you were engaged relating to electric light from the early fall of 1878 to the winter of 1879 and 1880.

Objected to as immaterial and irrelevant.

A. I was engaged in experimenting to devise a complete system of electric lighting by electrical incandescence distributed in a manner analogous to gas.

13 3 Q. Was an electrical meter a necessary part of such a system?

A. It was.

4 Q. The issues in this interference as defined by the Patent Office are:

FIRST. An electrical meter consisting of a cell, a spring suspended electrode and an index and scale.

SECOND. The combination in an electrical meter of a cell, a spring suspended electrode therein, and means controlled thereby, for reversing the circuit through the
14 cell to cause each electrode to become alternately anode and cathode.

THIRD. The combination in an electrical meter of a cell, a spring supported electrode therein, and means controlled thereby, for registering the rise and fall of such electrode in the cell. Please state when you first conceived the idea of the invention stated in these issues, when and what experiments were performed by you relating to the same, and when and what apparatus was constructed by you embodying the invention re-
15 ferred to?

> Objected to as incompetent if intended to contradict the allegation contained in the preliminary statement filed by witness, and notice is given that a motion will be made to strike out any and all testimony which may be given by the witness and having such a tendency.

A. I conceived the invention in October, 1878. In
16 October and November, 1878, I constructed apparatus embodying the issues.

5 Q. Please describe the apparatus referred to in your last answer as embodying the issues in this interference?

A. The apparatus while differently designed is fully explained in my specifications of the application in interference, and is illustrated in the drawing forming part of the application, a photograph of which I now produce.

> Photographic copy referred to by witness is

> offered in evidence by counsel for Edison, and 17
> marked Edison's Exhibit "Copy Drawing." Subject to correction by the original drawing.

6 Q. How many meters of the character described in the specification in interference were made by you or under your direction subsequent to October, 1878?

A. I should say a half a dozen.

7 Q. Were these meters placed in circuit and put in use in your laboratory?

A. Yes. 18

8 Q. About when were they placed in circuit as near as you now remember?

> Objection same as question 4.

A. Soon after they were made.

9 Q. Did you disclose to your assistants the invention at or about the time of its conception, and were they familar with the experiments and apparatus made by you? 19

A. Yes.

10 Q. Have you examined the specification and drawing of the English patent of John Toby Sprague, No. 4762 of 1878?

A. I have.

11 Q. Please state the purpose for which you examined said patent, how thorough your examination was, and what was the result of that examination and when it was made?

A. I examined this patent very thoroughly, soon 20
after notification of interference was received. I was unable to see how the apparatus could work therein described and shown in the figures 12 and 13.

12 Q. Please examine the specification and drawing of the patent referred to and state whether in your opinion the specification and drawing disclose to a person skilled in electrical matters and in mechanics an operative or working device for measuring electricity and whether such a person without the exercise of in-

21 ventive skill could from them construct an operative or working meter?

A. It is the blindest description I have ever seen in a patent specification even in the present state of the art, I do not think that any apparatus could be constructed by an expert from that specification which would work. To my mind it is utterly blind. I refer to the figures 12 and 13 and also to the specification relating thereto.

22 Adjourned to Friday, November 20th, 10 A. M.

NOVEMBER 20th, 1885.

Met pursuant to adjournment,

Same counsel.

23 13 Q. Please describe the construction and operation of the apparatus referred to in your fifth answer?

A. The apparatus consisted of a cell with a fixed copper cylinder in the cell. This cell was filled with sulphate of copper. The other electrode was a plate of copper suspended by a spring. A lever connected to the plate came in contact with electrical stops at the extremity of the movement of the plate, in either direction. When the plate had become heavy by deposition of copper it moved down into the liquid until the lever
24 touched one of the contact points closing an electric circuit, which actuated a reversing apparatus for reversing the direction of the current through the electrode of the cell. The plate then became lightened from copper taken off of it by electrolysis, which continued until the lever came in contact with the upward point. When the current became again reversed, and so on. A rachet wheel and magnet actuating a counter recorded the number of reciprocations of the plate.

14 Q. In your answers to questions 6, 7 and 8 you state that some half dozen meters of the character de-

scribed by you in your last answer were made after 25
October, 1878, and placed in circuit and put in use in your laboratory soon after they were made; please state as nearly as you now remember the months and year in which they were so made and used?

Same objection and notice of motion as to question 4.

A. November, 1878.

26

Counsel for Edison here give notice that if it be found that there is any variance between the testimony on behalf of Edison and the facts stated in his preliminary statement they will, at the proper time, move to amend the preliminary statement.

Adjourned to November 27th, at 10 A. M.

--- 27

Met pursuant to adjournment.

Same counsel as before.

Adjourned to December 2d, 11 A. M.

Met pursuant to adjournment. 28

Present—Same parties as before.

CROSS-EXAMINATION OF MR. EDISON:

15 x-Q. What were the names of the assistants to whom you alluded in answer to question 9?

A. John Ott, John Kruesi, Charles Batchelor, Martin Force, Francis Jehl and others whom I do not recollect now.

29 16 x-Q. You state in your preliminary statement in this case that you made sketches of models embodying the invention described in this interference in December, 1878: where are those sketches and models?

A. I can't find any sketches or models. I thought I had them.

17 x-Q. Then there are no such sketches and models now in existence, are there?

A. I cannot find them.

18 x-Q. Have you looked or caused others to look?

30 A. My counsel has looked through my sketchbooks; I have none. I have had one of my assistants look through my laboratory in New York for models, but he did not find any meeting the accounts of this interference. A great deal of the old truck at Menlo Park was broken up and not brought to New York.

19 x-Q. He found other models of meters, did he not?

A. Yes.

20 x-Q. You also say in your preliminary statement
31 that you put the same in actual use early in 1880; are you sure that that was the date?

A. Yes.

21 x-Q. How do you know that?

A. From memory.

22 x-Q. Is that all?

A. Yes.

23 x-Q. Do you remember how many machines you put in use then?

A. I think there were two or three different kinds of
32 the same thing.

24 x-Q. Do you remember how they differed?

A. Different in design; the experiments were more to determine other factors rather than the mechanism for recording.

25 x-Q. What other factors?

A. Deposition of the metal, the accuracy of the same, the evaporation of the liquids and other phenomena connected with electrolysis.

26 x-Q. Then no particular attention was paid to the 33
form of mechanism; is that true?

A. Yes; to a certain extent.

27 x-Q. To what extent?

A. In all these meters which have mechanism whereby a gain or loss of weight serves to give motion to the mechanism there is the defect of friction of the mechanism, and, while this is a small factor where heavy currents can be used and does not count greatly against the accuracy, in my system it was essential to use very weak currents and very slight increases and losses in 34
the weights of the plate. Hence, it was essential to have mechanism which would be very delicate. Even up to the present time the most delicate mechanism that has been made does not give a true record when very weak currents are used.

28 x-Q. Then, if I understand you, at the time that you made these experiments in 1880, the mechanism of your machines was not satisfactory?

A. Both the mechanism and the amount of deposit was not satisfactory. 35

Adjourned to Saturday, Jan. 30, 1886, 11 A. M.

THOMAS A. EDISON.

NEW YORK, Jany. 30, 1886.

Met pursuant to adjournment.

Present—Counsel as before. 36

At request of counsel for Sprague an adjournment was taken to Thursday, February 4, 1886, at 11 A. M.

FEBRUARY 4TH, 1886.

Met pursuant to adjournment.

Present—Same parties as before.

Adjourned to meet upon agreement of counsel.

37

IN THE U. S. PATENT OFFICE.

SPRAGUE,
Application filed May 9, 1881,

38 AGAINST — Interference. (Case B.)

EDISON,
Application filed January 31, 1881.

STATE OF NEW YORK,
City and County of New York, } ss.:

I, MORRIS E. STERNE, a Notary Public in and for the
39 City, County and State of New York, do hereby certify that the foregoing deposition of Thomas A. Edison was taken on behalf of Thomas A. Edison in the above-entitled interference in pursuance of the notice hereto annexed, before me at No. 65 Fifth avenue in the City of New York, on the 17th and 20th days of November, 1885, and the 2d day of December, 1885. That said witness was by me duly sworn before the commencement of his testimony; that said testimony was by consent of counsel written out by
40 Nora McCarthy; that J. E. Hindon Hyde, counsel for Sprague, was present during the taking of said testimony; that said testimony was taken at No. 65 Fifth avenue, in the City of New York, and was commenced at 11 o'clock, A. M., on the 17th day of November, 1885, and was continued pursuant to adjournment and further notice on the 20th day of November, 1885, and the 2d day of December, 1885, and was concluded on the last-mentioned day, and that I am not connected by blood or marriage with either

of said parties or interested directly or indirectly in 41
the matter in controversy.

In testimony whereof I have hereunto set my hand and affixed my seal of office, at New York City, this 24th day of September, 1888.

MORRIS E. STERNE,
[SEAL.] Notary Public,
N. Y. Co.
No. 278.

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43

44

45 ORANGE, N. J., August 9th, 1888.

Met pursuant to agreement.

Present—L. E. CURTIS, ESQ., counsel for Sprague; R. N. DYER, ESQ., counsel for Edison.

CHARLES BATCHELOR, a witness produced on behalf of Edison, being duly sworn, deposeth and says as follows, in answer to questions by counsel for Edison:

46

1 Q. What is your name, age, residence and occupation?

A. Charles Batchelor; age 42 years; residence 225 East Seventeenth street N. Y.; occupation assistant to Thomas A. Edison.

2 Q. How long have you been connected with Mr. Edison?

A. Since the early part of 1870.

3 Q. Were you connected with him during his elec-
47 tric lighting experiments in 1878 and 1879, and if so, in what capacity?

A. I was, as chief assistant.

4 Q. Did Mr. Edison make any experiments in regard to electric meters employing electrolytic or decomposition cells, and if so, when were these experiments commenced?

A. Mr. Edison did make many such experiments, and to the best of my recollection they were commenced in the latter part of 1878.

48 5 Q. What was the character of the experiments that came within your own knowledge that were make by Mr. Edison in 1878, relating to electric meters employing decomposition cells?

A. The experiments that I remember in regard to decomposition cells, were as follows: It seemed to be a favorite idea with Mr. Edison to measure electricity by means of depositing the metal and making the weighted plate tell, first, by weighing and afterwards by recording the amount of electricity that passed. The first experiments of this kind that I remember

were simply electrolytic cells in which the metal was 49
taken off one plate and deposited on the other, one of which plates was weighed in order to tell how much current has passed. Mr. Edison also made experiments with a similar cell, in which the plate to be weighed was provided with a pointer, which, as the metal got heavier would indicate the amount of current that was passed. This plate was suspended by a spring in some cases, and in other cases was mounted on a counter-balance arm so that the plate fell and rose in
the liquid as the current was reversed. He also made 50
meters on the electrolytic principle that were automatic in their action, inasmuch as the weighted plate would pull down a scale beam, and at a certain point would reverse the current so that the other plate could receive a larger portion of metal, and so pull the scale beam in the opposite direction. On such devices recording arrangements were placed which would keep a record of the current that had passed by counting the number of oscillations that the lever had
made. He also made other devices where a 51
number of plates were placed on a shaft, and where two or more were always in the liquid, one of which was increasing in weight. When the increase of weight had reached a certain point the wheel would naturally turn slightly in one direction, which would bring another of the plates into the liquid and pass one plate out of the liquid.

6 Q. I call your attention to the photographic copy of a drawing which is marked in evidence Edison's Ex-
hibit Copy of Drawing. Were any of the meters ex- 52
perimented upon by Mr. Edison in 1878 the same in principle of construction and operation as the meters shown by this drawing, and, if so, to what extent?

A. Yes; I remember Mr. Edison experimenting in the latter part of 1878 on the meter that was the same in principle and construction and operation of the drawing referred to. It was practically the same thing as the meter shown by this drawing.

7 Q. How extensive has been your experience in the construction of electrical apparatus, and what, if any,

53 experience have you had in constructing electrical apparatus from descriptions and illustrations contained in patents and other publications?

A. For the last eighteen years I have been employed in making apparatus from pen and pencil description and from Patent Office specifications, and I consider myself an expert in such manufacture.

8 Q. I call your attention to the English patent of John Toby Sprague, No. 4762, dated 22d of November, 1878. Have you ever examined this patent, and, if so,
54 for what purpose?

A. I have carefully read the patent, and have particularly considered it in regard to the proposed method there of measuring the current electrolytically, as shown in Figures 12 and 13.

9 Q. Please state whether or not in your opinion the specification and drawing of that patent are sufficiently clear to enable you to make a complete working device by the following of the description and drawing?

A. They are not sufficient, and are exceedingly vague.
55 The description is entirely insufficient to enable me to make from it a working apparatus such as he proposes. In fact, I do not think that any one can make a workable device from such a vague description and drawing. The patentee states what he desires to do, but does not provide any clear method of making the apparatus to do the work, but leaves it entirely to the inventive genius of the man who tries to make the apparatus to accomplish what he proposes.

56 Cross-examination waived.

CHAS. BATCHELOR.

Sworn to before me this ninth day of August, A. D. 1888, at Orange, N. J.

WM. J. KEARNS,
Notary Public
In and for New Jersey.

57

JOHN F. OTT, a witness produced on behalf of Edison, being duly sworn, deposeth and says in answer to questions proposed by counsel for Edison

1 Q. What is your name, age, residence and occupation?

A. John F. Ott, age 38; residence, 276 High street, 58
Orange; occupation, Superintendent of the Laboratory of T. A. Edison.

2 Q. How extensive has been your experience in the construction of electrical apparatus from the descriptions and drawings of patents and other publications?

A. I learned my trade as an instrument maker in 1864, and then I served four years at instrument making. Then I worked in New York at the construction of Patent Office Models, and from there I went into Mr. Edison's employ about 18 years ago, since which time 59
I have been daily employed in the construction principally of electrical apparatus of various kinds. This work I have done from pencil sketches and descriptions. I have also made a good deal of apparatus from published descriptions and drawings contained in patents and periodicals.

3 Q. I call your attention to the English Patent of John Toby Sprague, No. 4762, dated 22d November, 1878. Have you ever examined this patent?

A. I have examined this patent very carefully with 60
reference particularly to the proposed electric meter illustrated by figures 12 and 13.

4 Q. Are the specification and drawing of this patent sufficiently full and clear to enable you to make a working apparatus from it?

A. I do not consider it so. I have examined the specification and drawing critically and I fail to understand what the construction is intended to be. I do not think the specification is sufficiently full or the

61 drawing sufficiently clear to enable anybody to make an operative meter from it.

JOHN F. OTT.

Sworn to before me the 9th day of August, A. D. 1888, at Orange, N. J.

WM. J. KEARNS,
Notary Public, in and for New Jersey.

62 Cross-examination waived.

63

64

STATE OF NEW JERSEY, } ss.: 65
County of Essex, }

I, WILLIAM J. KEARNS, a Notary Public, within and for the State of New Jersey, do hereby certify that the foregoing depositions of Charles Bachelor and John F. Ott were taken on behalf of Thomas A. Edison, in pursuance of the notice hereto annexed, before me at the laboratory of T. A. Edison, Esq., in Orange in said county on the 9th day of August, A. D. 1888, that each of said witnesses was by me duly sworn before the com- 66
mencement of his testimony; that the testimony of each of said witnesses was written out by myself in shorthand and afterwards transcribed into longhand in in my presence; that said testimony was taken at Orange, aforesaid, and was commenced at 10:30 o'clock on the 9th of August, 1888, and was concluded on the same day; that I am not connected by blood or marriage with either of said parties, nor interested directly or indirectly in the matter in controversy.

In witness whereof, I have hereunto set my 67
hand and affixed my seal of office, at
[SEAL] Newark, in said County, this 9th day of August, 1888.

WM. J. KEARNS,
Notary Public.

68

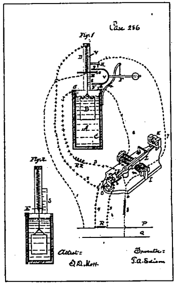
U. S. Patent Office.

Sprague vs Edison } Interference, Electrical Meters.

Case B.

"Edison's Exhibit, Copy Drawing".

Nov. 17. 1885.



Weston v. Edison (1882)

This 147-page pamphlet contains testimony given by Edward Weston, Benjamin Silliman, Jr., and several other Weston associates between January and April 1882 in a patent interference involving Edison and Weston. Included in the testimony are discussions of the technical and commercial development of Weston's dynamo. A number of pages contain significant handwritten comments by Edison.

1

In the Matter of the Interference. 2

WESTON, *vs.* EDISON, DYNAMO OR MAGNETO-ELECTRIC MACHINES.	*In the United States Patent Office.*

MESSRS. DYER & WILBER, 3
Attorneys of Record for Edison.

Take notice that on Monday next, 23d January, 1882, at 1 o'clock P. M., or as soon thereafter as practicable, at the office of E. Weston in the Weston Electric Light Company's Works, No. 23 Plane St., Newark, N. J., before competent authority, I shall proceed to examine the witnesses below named, and possibly others, on behalf of said Weston.

The examination will continue from day to day until completed.

Respectfully,

M. BAILEY,
Att'y for Weston.

4 Witnesses:

Edward Weston, Newark.
John Holmes, "
Geo. Harrell, "
Robt. Carmichael, "
Joseph Bradley, "
Staniar & Laffey, "
—— Douglass, Phœnixville, N. J.
Scott & Whitcomb, Boston.
W. L. Stevens, "
Henry Tohla, Jersey City.
—— Van Winkle, New York.
—— Craske, "
Geo. Jackson, "
Prof. Siliman, New Haven.
L. Broadbent, Belleville, N. J.
W. B. Hollingshead, Stamford.
John Gormley, Watertown.

5 And possibly others.

Washington, D. C.,
January 20th, 1882.

Good service.

THOS. A. EDISON,
By GEO. W. DYER, for
DYER & WILBER.

6

BEFORE THE COMMISSIONER OF PATENTS. 7

IN THE MATTER
of the
Interference between the application of EDWARD WESTON, filed May 31st, 1881, for an improvement in Dynamo or Magneto Electric Machines;
and
The application of THOMAS A. EDISON, filed February 21st, 1881, for an improvement in Magneto or Dynamo-Electric Machines.

Wilber will testify that Page [illegible] came to him & [illegible] stated they were going to [illegible] Russia [illegible] dynamos, [illegible] asked him [illegible]

Depositions of witnesses examined on behalf of Edward Weston, pursuant to the annexed notice, at the office of Edward Weston, in the Weston Electric Light Company's Works, No. 23 Plane St., Newark, New Jersey, January 23d, 1882.

Present—

MARCELLUS BAILEY, Esq.,
On behalf of Edward Weston, and 9
GEORGE W. DYER, Esq.,
On behalf of Thomas A. Edison.

It is agreed by counsel for the respective parties that the depositions of witnesses under said notice may be taken at the office of L. E. Curtis, No. 120 Broadway, New York City.

EDWARD WESTON, being duly sworn, in answer to interrogatories propounded to him by Marcellus Bailey, counsel for Weston, deposes and says as follows:

10 1 Q. What is your name, age, residence and occupation, and are you one of the parties to this interference?

A. Edward Weston, age 31 years, residence Newark, New Jersey, occupation chemist and electrician. I am one of the parties to this interference.

2 Q. State as near as you can when you conceived the idea of uniting the longitudinal conductors or active coils or bars of the rotary armature of a dynamo or magneto-electric machine by an end-disk connection, and what led you to it?

A. In the early part of the year 1875, I conceived
11 of the use of an end disk connection connecting the longitudinal conductors of the armature of a Dynamo Electric machine. I was led to it on account of the difficuly I had experienced in winding an armature with wire, or strips of sufficient thickness to enable me to obtain a machine of very low resistance and low electro-motive force, without the crossing of the wires at the end of the armature.

3 Q. State what you did subsequently towards developing and reducing to practice the invention, and the various applications, if any, which you made of this mode of connecting the longitudinal conductors; give a connected history of your efforts in this direction, specifying dates and circumstances, as far
12 as practicable.

A. About the month of July, 1875, I constructed a small machine having longitudinal conductors and end disk connection. The armature core of this was built up of a series of thin iron rings fastened to a wooden hub, through which the shaft passed. The iron rings and copper disk for this machine were made at the factory of Stevens, Roberts & Havell, Newark, New Jersey, together with some other work necessary for the machine. The machine was finished and was tried in my laboratory, and also at the establishment of Harris & Weston, 180 Centre Street, New York. This machine had

only one commutator. In 1877 I built another 13
machine, almost identical with the one described, but it had two circuits and two commutators, which could be connected up either in series or multiple arc. This was in the early part of 1877. In the early part of 1879 I again took up the subject, and constructed several machines of this kind. One of these machines was tested in the plating shop of the firm of Roberts & Havell, of Newark, New Jersey. These machines were all comparatively small machines. About this time several parties inquired about machines for electro-metallurgical purposes, which could be used without a stream of water to cool the machine. I may mention, 14
amongst others in this connection, Prof. Silliman of New Haven, Prof. Douglass of Phenixville, Mr. Craske of New York, and Mr. Scott, of the firm of Whitcomb & Co., of Boston. From the results I had obtained from the small machines, I told Prof. Silliman and the other gentlemen that I could build such machines as they inquired about, and such machines would be much more efficient than any machine then in the market. I pointed out to Prof. Silliman and a number of other gentlemen that the armature of our so-called electric light machine, if wound with copper bars, would answer the purpose admirably. I pointed out the fact,
however, that the armature could not be wound 15
with copper bars, without the use of flattened end-pieces or disks, for connecting the various sections of the armature together. I also pointed out the fact that the machine would be identical in construction and operation with our ordinary light machine in all other respects, except that the commutator would have to be placed inside the bearings, because it would be impossible to lead the heavy conductors, either through the shaft, or through the bushing on the shaft, as was done in the ordinary or, so-called, electric light machine.

After careful calculation, I found that the arma-

16 ture of our No. 4 machine would answer the purpose; and on the 11th day of April, 1879, I gave instructions to one of my men to order copper bars and copper sheets for the disks for this armature. They were ordered from Messrs. Staniar & Laffey of East Newark. I then submitted the project of building a new frame for this machine to the Board of Directors of the Company, who were operating under my patents and manufacturing Dynamo-Electric machines. I wished to obtain their consent to make this machine, and submitted a rough estimate of the cost. They would not approve of the matter, unless I could obtain a certain amount of
17 cash down from Prof. Silliman. I explained to them that I was under certain obligations to Prof. Silliman to complete this large machine and that I did not think it was wise to exact such terms, because, if the process of purifying copper for which the machine was to be used proved successful, we should no doubt have a large sale of machines of this class. Shortly after this I completed the drawings for the frame, or, more properly speaking, field magnets; but, at the time, I could not obtain the consent of the Directors to construct the machine, partly because we were short of money, and also had some few large machines of our regular type on hand.

18 From that time on I described the machine to a number of persons, and proposed at the earliest opportunity to substitute this type of machine for our large electro-typing and electro-plating machines; and in January or February of 1881, I told the foreman of our shop not to build any more of the large electro-typing or electro-plating machines, as I proposed to use our ordinary electric light machine armatures wound with copper bars and disks instead.

4 Q. What has become of the machine which you constructed in the month of July, 1875?

A. Parts of this machine are still in my posses-

sion; I cannot state where the other parts are; one 19
of the men, who works in the laboratory, has put the parts, which remain, away, and we could not find them to-day; he is in Chicago, and he will be here in about a week.

5 Q. Have you any drawing of that machine in your possession? If you have not, will you please make a sketch representing the general organization of that machine, particularly as regards the armature?

A. I have no drawing of the machine in my possession; I have made a rough sketch of the machine and armature, and marked the various parts so that they can be understood, and have also added 20
a short description of the sketch

The sketch referred to is produced by witness, and the same is hereby put in evidence and marked "Weston Exhibit No 1, W. H. H. Exr."

6 Q. You have stated that the machine built by you in 1877 was almost identical with the one represented in Weston Exhibit No. 1; with respect to any differences between these two machines, to what did these differences relate—to the end-disk connection, or to other parts of the machine?

A. To other parts of the machine; there were, 21
however, two end-disk connections in the 1877 machine; the other differences I have already referred to; the iron rings, however, were replaced by thin iron disks in this case, and there was no wooden hub; this may be considered an immaterial difference.

7 Q. In so far as the end-disk connection was concerned, did the 1875 machine prove satisfactory on trial?

A. It did

8 Q. Did you test it more than once; if so, how many times?

A. Yes; the machine was used at various times,

22 and some rough measurements of the strength of the current obtained from it were made.

9 Q. Answer the same questions, to wit, questions 7 and 8, in respect to the 1877 machine?

A. The results were substantially the same; differing only in degree.

10 Q. At what time in the year 1877 was your 1877 end-disk machine made?

A. In the early part; I should say somewhere about the month of April; it was tried as soon as completed.

11 Q. Is that machine still in your possession?

A. No, sir.

12 Q. What has become of it, if you know?

23 A. I cannot say, positively; it may possibly have been destroyed in the fire which destroyed part of our factory; I lost quite a number of valuable things at that time; the fire occurred either in the latter part of 1879 or the early part of 1880; I think about January 23d, 1880.

13 Q. Have you any drawing of that machine in your possession; if you have not, will you please make a sketch of that machine, particularly as regards the armature?

A. I have no drawing of the machine in my possession; I have made a rough sketch of the armature, and marked the various parts so that they
24 can be understood, and have added a short explanation of the same.

> The sketch referred to is produced by witness, and the same is hereby put in evidence and marked "Weston Exhibit No. 2, W. H. H., Exr."

Adjourned to Tuesday, January 24th, 1882, at 10 o'clock A. M.

NEW YORK, Jan'y 24th, 1882, 10 o'clock A. M. 25

Met pursuant to adjournment.

Present—

Counsel for the respective parties as before.

The witness, EDWARD WESTON, continuing, says: The commutator, as shown in the sketch, is a cylindrical commutator in which the strips are parallel with the axis, but they are curved in the direction of the periphery of the axis; in other words, they are slightly helical, so that the brushes press on the respective strips, and are, consequently, in contact with nearly all the wires included in this
part of the circuit. 26

This form of commutator was modified somewhat by making the strips concentric with the axis and with the planes of the strips at right angles to the axis; the result was substantially the same in each case, but the latter form of commutator was a little more easy to make. The shape of these strips on this latter form of commutator (which may, for convenience sake, be called the *disk* commutator) was also slightly modified.

14 Q. You have stated that in the early part of 1879 you constructed several machines in which the conductors of the armature were united by an
end-disk connection. Have you any of those ma- 27
chines, or parts of the same, still in your possession, and if yea, please produce the same?

A. I have; the armature, which I now produce, is part of one of the machines.

> The armature produced by witness is put in evidence and marked "Exhibit Weston No. 3, W. H. H. Exr."

This armature is composed of a central iron core through which the shaft passes, surrounded by a copper conductor connected at one end by a copper disk. The cylindrical copper conductor, by its rotation in the field of force, cuts the lines of force

28 at right angles, in a manner identical with the cylindrical armature described in my Letters Patent No. 209,532. dated October 29th, 1878. The copper cylinder may be looked upon as an infinite number of parallel conductors laid side by side on the periphery of the iron core and parallel with the axis in all directions except at the end. The copper disk at the end connects these parallel conductors on each side of the axis diametrically across in a manner substantially the same as that described in the patent above referred to. And the disk may be looked upon as an equivalent of the cross connecting wires at the ends of the armature in the
29 patent referred to, and carries the current from one side of the armature to the other in the same way.

It will be noticed that the cylindrical conductor and copper disk are insulated from the iron core by paper. The brushes in this machine were made to bear upon the projecting end of the cylinder; that is to say, the end opposite to the copper disk end; and the line of flow of currents in the conductor is substantially the same as the line of flow of the currents in the machine, described in the patent No. 209,532, viz.: On one side of the conductor diametrically across the end disk to the brush, to the external circuit, back to the brush on the opposite side of the cylinder. In other words, the currents
30 flow parallel with the axis on both sides, and across the end disk, in the same way as in the wires of the armature in the machine, described in patent No. 209,532.

So far as I am at present aware, this is the only part of any of these machines that is now in existence.

15 Q. What has become of these other machines, so far as you know or have been able to ascertain?

A. I cannot state positively anything definite in relation to this matter; the company who were then working my patents were not financially strong, and I was compelled, from lack of means,

to put these things on one side; the consequence 31
was, that I lost many valuable pieces of apparatus at the time of the fire in our factory, and after our removal to the new factory in Plane street, Newark, New Jersey, much of this apparatus was allowed to stand until I could make provision for its assortment and arrangement.

About this time we hired a new superintendent, who was new at the business, and, in straightening out the remnants of the fire, he undertook, without my knowledge, to straighten out the apparatus to which I have referred, and before I was informed of it, he had destroyed more or less, and was about to sell a large part of it for scrap metal; I 32
was very much annoyed and astonished to find that he had destroyed in this way quite a number of machines and parts of machines which were of great value to me. I cannot, however, state whether these machines were destroyed by the fire or by him.

16 Q. Please sketch and describe the machines made in the early part of 1879, which thus disappeared?

A. I have made a sketch of one of the machines made in the early part of 1879; this is the machine which I have already described as having been tested in the plating shop of Messrs. Roberts & Havell, of Washington street, Newark, New Jersey, in the 33
early part of 1879.

> The sketch referred to is produced by witness, and the same is put in evidence and marked "Exhibit Weston, No. 4, W. H. H., Exr."

The general construction of the machine was the same as that described in my patent No. 211,311, and dated January 14th, 1879; the field magnets being made, however, entirely of cast iron; the circuits on the armature were also the same; but instead of the over-lapping wires at the end, thin copper disks were used to connect the parallel con-

34 ductors; these disks took up much less space than the wires and reduced the internal resistance of the machine considerably, thus increasing its efficiency; the disks, however, performed no different function from that of the over lapping wires in an electrical sense; this machine was quite small and the field magnets corresponded exactly in size and every other respect with field magnets of our 00 light machine; in the sketch which I have made, Fig. 1 shows the field magnets with armature *a*, in position, and Fig. 2 the armature A has the conductors running parallel to the axis on both sides of the axis and connected at each end to the copper disks
35 C D and C D', and the wires leading from the junctions of the copper disks and parallel conductors were led through the steel bush S B to the commutator C; Fig. 3 is a diagramatic view of the conductors and the copper disks, and Fig. 4 is a plan or end view of one of the back disks; this machine differed from the 1875 and 1877 machines only in respect to the arrangement of the connection of the conductors; in the one case they were connected up in multiple arc, in the other in series.

In the case in which the wires are connected in multiple arc it is only necessary to use one disk; on the contrary, in the case in which it is desired to use
36 the conductors in series, it is necessary to use the number of disks corresponding with the number of loops or parallel conductors at each end of the armature.

17 Q. Suppose you had not used the disk-end connection in your 1875 and 1877 machine, how would the conductors in those machines have been connected, and how would the ends of the armature have appeared?

A. The conductors would then have been connected in a series of independent loops, by that portion of the wire which passes nearly diametrically across the end of the armature furthest from the commutator; in that case the layers of wire on the

end of the armature would have overlapped each 37
other, and they would have extended out towards the bearing considerably, making a very awkward looking job, and it would have given great trouble to keep them in position; in an electrical sense the machine would not have been anywhere near as good as if the copper disk had been used, because as each loop was added a greater length of wire would have been required to make the complete loop, and the resistances of the first loops would have differed considerably from the last ones; such an armature would not have had a uniform current in each convolution or loop of the wire, owing to the fact of the length and the resistance of each convolution 38
differing.

Again, all the wires on the armature would not have been connected together with this system of winding, whereas, by the use of the disk all the wires on the armature were connected together.

18 Q. At the time you made the machine, Exhibit Weston No. 4, were not both methods of winding the armature known, to wit: in multiple arc and in series?

A. Yes, sir; very well known to persons skilled in the art.

19 Q. State whether or not, assuming the cross-disk connection had before been used with multiple arc winding, would there be difficulty, mechanically 39
or electrically, in applying the same method of connection to an armature wound in series, as represented in your Exhibit No. 4?

A. There would be no difficulty which anyone with ordinary mechanical skill could not overcome; it is simply a question of making proper joints between the copper disks and the conducting bars or loops.

20 Q. State, as nearly as you can, at what time in 1879 the machine represented in your Exhibit No. 4 was completed?

A. It must have been prior to the time of giving

40 the order for the copper bars and disks for the large machine, which, to the best of my recollection, was April 11th, 1879.

21 Q. How soon after was it tested at the shop of Roberts & Havell?

A. Very shortly after its completion; I could not state the exact time; it could not, however, be more than a few days.

22 Q. At the time the test was made, were there any other dynamo-electric machines in use at the shop of Roberts & Havell?

A. Yes; in their general work they used a machine like that one described in my patent No.
41 108,082, dated July 18th, 1876.

23 Q. In what respect, if any, did your disk-end connection machine differ in general appearance, as regards the frame, &c., from Roberts & Havell's machine?

A. It had flat magnets, which were open to view and resembled exactly in appearance what was known as our electric light machine. On the contrary, the machine which they used regularly in the operation of plating was cylindrical in form, and the magnets were hidden from view by covers on each end of the cylinder. It was one of our regular type of plating machines.

This machine also required a stream of water to
42 keep the magnets and armature cool; whereas, the modified electric light machine required no water.

24 Q. So far as you recollect, did you test more than one machine at the shop of Roberts & Havell during the fore part of 1879?

A. No, sir.

See fol. 118

25 Q. Have you the drawings of the large disk-end connection machine which you say was completed in October, 1879? If yea, please produce them.

A. I have, and herewith produce them.

The drawings referred to are produced by witness, six sheets in all, and are put in evi-

dence and marked "Exhibit Weston, No. 5, 43
W. H. H., Exr."

26 Q. State whether these drawings are working drawings, and give such explanation as may be necessary to an understanding of them.

A. They are working drawings of a machine designed for the Phenixville Copper Company of Phenixville, Pennsylvania. The machine was to be used for the purpose of refining copper. The drawings are made to a scale of one-half. Sheet No. 1, shows a side and end elevation of the machine, with the shaft in its bearings; the bearing further from the pulley is the place where the commutator is fixed.
This machine was specially designed to allow of the 44
commutator being placed inside the bearing, between the end of the bearing and the armature. Owing to the dimensions of the bars or copper conductors on the armature, and the volume of the current which would have been obtained, the space between the end of the bearing and the end of the flanged air-tube, which is common to my machines of this type, was unusually large, so as to admit of the use of a very long and heavy commutator.

No- See fol. 66

It will be noticed in this drawing that the bearing at this end of the machine has been curved outward, in order to secure more space at this point.
The brushes for this machine were also unusually 45
large, so as to avoid loss of useful effect by the current heating these parts of the machine.

Sheet No. 2 is a plan of the same machine, with the addition of the brass quadrant in front, for the purpose of adjusting the position of the brushes in relation to the commutator.

Sheet No. 3 is a plan view and sections of the base.

Sheet No. 4 shows details of the bearings.

Sheet No. 5 shows details of the quadrant, with the slotted grooves through which screws were to be passed to hold the quadrant in position, and at the same time to permit of its adjustment within

46 the limits of the slots and consequent adjustment of brushes in relation to the commutator.

Sheet No. 6 shows full sized details of the massive brush holder and rod which carried the same, and by which the brush holders were to be connected to the quadrant.

This machine differed radically in design and appearance from our then well known standard light machines, in the following respects:

The magnets were changed from the horizontal to the vertical position, and the machine stood on a base somewhat similar to the base used in our obsolete form of light machines. These changes were
47 necessitated by the enormous size of the conductors or bars, which were to be used on the armature; the total cross-section of the conductor being somewhere near a square inch. The machine also differs from our light machine in respects to the position of the commutator, as I have already pointed out. The usual and very convenient plan of placing the commutator outside of the bearing had in this case to be abandoned, on account of the large size of the conductors leading to the respective strips or sections of the commutator. The quadrant also differed very radically from the quadrant used on the light machines, and was almost identical
48 in construction with the quadrant on our large sized circular or ordinary plating machines. The brush holder also differed very radically from the light machine brush holders, both in design and size. In fact the whole machine was designed with special reference to the purpose for which it was intended, viz.: to furnish currents of enormous volume, and to have a very low electromotive force. The armature for which this machine was designed was exactly the same in size and construction as the armature of our so-called No. 4 light machine; but the shaft was made longer to accommodate the large commutator. For this reason it was unnecessary to make detailed drawings

of the armature, as we were regularly manufacturing such armatures. The bars of copper were to be 49
of the exact size of the slots or grooves in the periphery of the armature, minus the space required for the insulation, and the copper disks were to be one quarter of an inch thick. There were sixteen slots or grooves on the periphery of the armature. this called for eight loops and sixteen disks for each of the parallel conductors, or in all, sixteen loops. The drawings were shown to several parties, and the construction of the armature was explained.

The copper disks were to be cut out so as to slip inside the projecting four extensions and ears from the loops were to be made to connect with diame- 50
trically opposite ears at the back or pulley end of the armature, and the disks at the front end were made in the same way, except that one of the ears was to be placed one-sixteenth of the total circumference of the armature out of the true diameter. The bars were to be screwed by copper screws to the lugs or ears of the disks, and as a further means of securing good electrical contact, the bars and lugs of the disks were to be what is technically known as sweat together; in other words, they were to be soldered together by as thin a film of solder as it was possible to obtain. The bars and disks were to be insulated from each other and from the iron core or armature by means of asbes- 51
tos paper.

I herewith produce a full sized No. 4 armature such as we were building at that time, and which was to be used in the machines, drawings of which have already been introduced.

> The armature referred to is produced by witness, and is put in evidence and marked "Exhibit Weston No. 6, W. H. H., Exr."

The disks and bars in this machine were to be connected up in the manner described by me in patent No. 209,532, that is, in series, and so that the two parallel conductors thus formed were con-

52 nected in multiple arc in the manner therein described. The connections of the junctions of the bars and disks were the equivalents of the loops therein described, and they were to be connected to the sections of the commutator in substantially the same manner; bearing in mind, of course, the difference in size of the conductors of the two machines. In the machine described in the patent, as I have already stated, the wires were led through the bushing to the commutator, while in the latter case it could not be done.

27 Q. Please explain how it was that after you made and tested your 1875 machine you did not
53 sooner make use of the disk-end connection in your business?

A. At the time named there were but very few Dynamo-electric machines in practical use in this country, and the use of such machines was limited almost entirely to electro-plating, and for the production of currents for the electric light, which was practically limited in its use, being confined mainly to colleges, and large schools or centres of learning. Neither was there any demand for such machines. The demand had, in other words, yet to be created. One or two men had made attempts to introduce such machines generally
54 amongst electro-platers, but the price asked for the machines prevented the sale of more than a few to some of the very large concerns engaged in the business of the electro-deposition of metals in this country.

From my own experience in that business and long continued use of machines for this purpose, I was perfectly convinced that if a cheap, reliable and easily managed machine could be designed and presented to electro-platers generally, they would soon give up the costly and troublesome ways then in common use for the generation of electricity by chemical means. With this object in view I designed the circular machine described in my patent

No. 108,082. This machine had many excellent 55
qualities; and amongst others was its low first cost and, from the peculiar construction of its armature, great durability. Owing to the simplicity of the commutator and other wearing parts of the machine, and the small amount of material which was required to produce a given effect, I selected this as being the best adapted to the general wants of the only customers of any consequence that you could then expect to secure, viz.: electro-platers and electro-typers. I succeeded in interesting some capitalists in this business and commenced to manufacture these machines. At the time named it would have been difficult, if not impossible, to obtain or- 56
ders for large and costly machines such as are now in demand. In other words, but few electro-platers and electro-typers could have been induced to purchase large and costly machines, and to succeed at all it was necessary to build a machine that was small, compact, cheap and easily managed, even though efficiency was sacrified to a large extent. With the then common knowledge in relation to the efficiency of machines and the influence of size in the respective parts of the machines, I do not hesitate to say that if I had attempted to introduce the machine to which you refer the business would have proved a failure.

The conditions, during the past two years par- 57
ticularly, have materially changed; the electric light has become a commercial success, and the business has developed enormously; whereas the business of the manufacture of Dynamo-electric machines in 1875 could be counted by a few thousands of dollars per month, it can now be estimated at hundreds of thousands of dollars per month, and there is a much greater demand for larger machines than there was for small ones then. Any person at all familiar with the development of the art and with general business principles can see that this changed condition of affairs has involved a large

58 amount of labor on the part of parties connected with the business, and has caused a demand for machines in which the question of efficiency is of the utmost importance, and the size and weight of the machines is not now taken into consideration except under special circumstances. In other words, the type of machine which has now become popular is radically different from the machines which were commonly known at the time to which you refer. These facts had great weight with me in my selection of the circular form of machine to which I have above referred.

59 As the business developed I began to see the importance of building more efficient machines, and urged upon the directors of our company the construction of the machine which is the subject-matter of this interference, both for the purpose of electric light and electrotyping, or, more properly speaking, electro-metallurgical purposes; but from the straightened circumstances of the company, which was endeavoring to carry on a very large business with a very limited capital, I was unable to induce it to do so.

28 Q. In your answer to the 4th interrogatory you state that parts of the 1875 machine are still in your possession, but that they could not be found
60 owing to the absence in Chicago of the man who put them away—please state what means, if any, you have taken to obtain them?

A. After failing to find them we have telegraphed to the man to ascertain what he did with them; they must have been misplaced by him at the time he was taking an inventory of the laboratory, which was about a week ago.

> Counsel for Weston states that the parts referred to can be obtained, he hopes, before the close of the examination of this witness, and that they will be introduced in evidence as soon as practicable.

Adjourned to Wednesday, January 25th, 1882, at 10 o'clock A. M. 61

Wednesday, January 25th, 1882, 10 o'clock A. M.

Present—Counsel for the respective parties as before.

Adjourned to Thursday, January 26th, 1882, at 10 o'clock A. M.

Thursday, January 26th, 1882, 10 o'clock, A. M. 62

Present—

> Counsel for Weston as before, and Frederic H. Betts, Esq., counsel for Edison.

Examination of Edward Weston continued:

29 Q. Have you found the parts of the 1875 machine referred to in the preceding interrogatory, if yea, please produce them?

A. Yes; and I herewith produce them.

> The parts referred to are produced by witness, and the same are put in evidence and are marked "Exhibit Weston No. 7, W. H. H., Exr." 63

30 Q. Referring to the small 1879 machine, illustrated in your Exhibit, No. 4, state for what purpose that machine was built and tested by you, and whether the tests were satisfactory?

A. The small machine was built for the purpose of determining the elements, so as to enable me to calculate the size and number of bars to be used on the large machine. For this purpose the machine was tested by the galvanometric methods and further tested by actual use in plating. The tests were satisfactory.

31 Q. Had these tests anything to do with deter-

64 mining the feasibility or practicability of the end-disk connection ?

A. None whatever. The substitution of the copper disks for the over-lapping wires at the end was well known to me at the time, and therefore it required no experiment to determine the feasibility or practicability of this plan of building an armature.

32 Q. You have testified that in April, 1879, you gave instructions to one of your men to order copper bars and copper sheets for the armature of the large machine represented in your Exhibit No. 5; state whether at or about this time you explained to any of your men how you proposed to wind the
65 armature, and if yea, state as near as you remember, what your explanation was and who the men were ?

A. I did at or about the time referred to describe the manner in which I proposed to wind the armature to several of my men; I described the construction of the armature in detail to them, explaining how the bars were to be connected to the disks, as I have already testified; I described the mode of winding and constructing the armature to Mr. J. C. Young, Mr. Levi Broadbent, Mr. Joseph Bradley, and later on to the young man who made the drawings of the large machine, which have already been introduced in evidence and marked Exhibit
66 Weston No. 5; the young man's name was H. M. Byllesby; I also described the construction of the armature in detail to a number of other persons.

33 Q. Are the persons named still in your employ ?

A. Only one of them has remained in the employ of the Company, viz.: Mr. J. C. Young; Mr. Bradley left us in 1879, and went to work for Mr. Edison very shortly afterwards; I believe he is still employed by Mr. Edison; Mr. Byllesby is also employed by Mr. Edison, and Mr. Broadbent is employed by a firm in New York, the name of which I do not now recollect; Mr. Bradley was foreman of the mechanical department in our factory at the

time referred to, and Mr. Broadbent had general charge of the winding and assembling departments. 67

Cross-examination of this witness reserved to Monday, February 13, 1882, at 10 o'clock, A. M.

New York, February 13, 1882.

Met pursuant to adjournment.

Present—

For Edward Weston, Counsel as before.
For Thomas A. Edison, F. H. Betts, Esq. 68

Cross-examination of Edward Weston by Mr. Betts:

34 x-Q. With whom were you connected in business in the early part of the year 1875 ?

A. George J. Harris; I also made an arrangement about this time with Messrs. Stevens, Roberts & Havell to manufacture and sell dynamo-electric machines; and for this purpose moved to Newark in the winter of the year named.

35 x-Q. What was your business with Mr. Harris ?

A. Electro-plating; I might state here that I believe another partner was taken in about this time, 69 whose name was George P. Warner, and Mr. Harris subsequently retired from the firm.

36 x-Q. When was your partnership with Harris terminated ?

A. I cannot state the exact date without an examination of papers which are not in my possession, but I am quite certain that it was in the early part of 1875.

37 x-Q. In whose possession are the papers which would enable you to state this date ?

A. Some of the papers, I have no doubt, are in the possession of Mr. Henry S. Lowe; others are, I think, in the possession of Mr. Harris' attorney,

70 John W. Taylor, I think his name is, who then had an office in Wall street, New York. I do not know what has become of the books of the concern, as I retired from the concern a short time after the middle of 1875.

38 XQ. What are the papers which would enable you to state with exactness when you retired from this firm?

A. The articles of co-partnership between Mr. Warner and myself and the agreement for the terms of sale of Mr. Harris' interest to Mr. Warner. The books of the concern would also enable me to fix this date. They may probably be in existence. I am
71 not quite sure of this, however.

39 x-Q. Can you give the date when you made the arrangement referred to with Stevens, Roberts & Havell?

A. Not the exact date, sir; I know, however, that it was prior to the month of July, 1875, because I moved to Newark about this time, to devote my attention more particularly to the business of manufacturing dynamo-electric machines and patent anodes for nickel-plating.

40 x-Q. In what business were you at the time that you say you conceived of the use of an end disk connection, connecting the longitudinal
72 conductors of the armature of a dynamo-electric machine?

A. In the business of electro plating.

41 x-Q. How long did you continue in the business of electro-plating?

A. From the year 1871 or '2 up to the year 1875.

42 x-Q. When did that business of yours terminate entirely?

A. My connection with it ceased in the latter part of the year 1875, or somewhere about from the middle to the latter part; I cannot tell when the business was finally given up by Mr. Warner, the remaining partner.

43 x-Q. Is there any way in which you can fix

exactly the time when your connection with that 73
business ceased?

A. Possibly there is; my impression is, however, that it would be difficult to fix the exact date.

44 x-Q. Did it cease before you made the arrangement you spoke of with Stevens, Roberts & Havell?

A. No, sir.

45 x-Q. What was your position in the electro-plating business which you spoke of?

A. Partner with Mr. Harris; and I practically conducted all the operations relating to the preparation of the work and plating of the same.

46 x-Q. Was your business a large one?

A. Not very large.

47 x-Q. Give some idea of its extent? 74

A. We employed, I should say, about 10 or 12 hands, possibly more, outside of my partner and myself.

48 x-Q. You stated, in answer to the second question, that you were led to this conception on account of the difficulty you had experienced in winding an armature with wire or strips of one thickness, to enable you to obtain a machine of very low resistance, and low electro-motive force, without the crossing of the wires at the end of the armature. When did you experience that difficulty?

A. Shortly after my business connection with 75
Messrs. Stevens, Roberts & Havell, when I undertook to build commercial dynamo-electric machines, and, for this purpose, commenced a series of investigations relating to the same.

49 x-Q. What was the nature of your agreement with Messrs. Stevens, Roberts & Havell?

A. They were to furnish money to enable me to design and construct a machine suitable to the requirements of the art at the time named. They were to furnish me also with ordinary facilities for the construction of such machines, and I was to receive a certain percentage of the profits arising from the sale of such machines. According to the

76 best of my recollection, there was no written contract between this firm and myself, as I had perfect confidence in Mr. Stevens, who was then the senior partner of the firm, and I had known him for quite some time, and had had more or less business dealings with him.

50 x-Q. Were Messrs. Stevens, Roberts & Havell responsible people of means?

A. Yes, sir; they were very large manufacturers of metal goods.

51 x-Q. What was the art for which you were, by your agreement with Stevens, Roberts & Havell, to design and construct a suitable machine?

77 A. Mainly for the purpose of electro-plating and electro-typing—or more generally, for the electro-deposition of metal. But I could see very plainly that there would be other important uses to which the machine could be put, especially if the business was properly prosecuted.

52 xQ. Were the machines which you expected to design and construct dynamo-electric machines?

A. Yes, sir.

53 x-Q. Was there, by your contract with Messrs. Stevens, Roberts & Havell, any limit placed upon the amount of money to be furnished by them to you for the purpose indicated?

78 A. No, sir; to the best of my recollection, none whatever.

54 x-Q. How soon after you made this arrangement with Messrs. Stevens, Roberts & Havell, did you commence work practically in the matter of designing and constructing dynamo-electric machines?

A. Almost immediately. There was very little interval between the first conversation that I had with Mr. Stevens in relation to this matter and the time of commencing work on the machines.

55 x-Q. You say there was very little interval. Will you please state about how much interval it was?

A. A cannot state the time, but think I should

be safe in saying that there was not more than two 79 weeks, if that much, time elapsed before commencing work.

56 x-Q. Can you state the time when you commenced, practically, to work constructing dynamo-electric machines?

A. Not any nearer than I have already done.

57 x-Q. Is there any means by which you could fix the time accurately?

A. Possibly there are; if there are, I am not at present aware of them; if you desire to know the precise date, I will endeavor to ascertain it.

58 x-Q. What facilities did Messrs Stevens, Roberts & Havell afford you for carrying out your arrangement with them? 80

A. They constructed parts of machines for me and paid the cost of the same, employing hands, or using men whom they had at the time in their employ, for this purpose.

59 x-Q. Did you have any place of business assigned to you—put under your direction?

A. No; but they loaned me some machinery to use in New York, which was put up in my laboratory.

60 x-Q. Where was your laboratory at that time?

A. In Canal street, New York, only a short distance from their place of business, which was then 180 Center street. 81

61 x-Q. How much of an establishment did you have at your laboratory, and what facilities for carrying on your work?

A. Not very good facilities, and not a very large establishment; I had a lathe, together with some tools necessary to use the same, and such generally useful tools as soldering irons, files, etc.; I had also convenience for driving the machines by means of the foot lathe at moderate speeds, and facilities for making electrical measurements; in fact my laboratory was moderately well arranged for general experimental work on a small scale.

62 x-Q. What were the facilities that you had

82 under your control under your arrangement with Messrs. Stevens, Roberts & Havell?

A. I had the use of their machine room and of the tools it contained.

63 x-Q. Were those well adapted for carrying on the work?

A. Only on a small scale.

64 x-Q. How long did that arrangement with Stevens, Roberts & Havell continue?

A. Up to July 10th, 1877.

65 x-Q. During that period, did you manufacture and sell any dynamo electric machines?

A. Yes, sir.

83 66 x-Q. About how many?

A. I don't know.

67 x-Q. State as near as you can?

A. I cannot give any idea of the number; according to the best of my recollection, it was in the hundreds.

68 x-Q. By what name were the said machines known in the trade?

A. They were known by the name of dynamo electric machines.

69 x-Q. Were they all of one class as to their mode of construction?

A. No, sir.

70 x-Q. How many forms of such machines did
84 you manufacture?

A. I cannot tell how many; but quite a number of machines were made, for special purposes, which differed somewhat from the machines more generally constructed.

71 x-Q. Well, about how many varieties of machines did you make during that period?

A. Possibly as many as ten.

72 x-Q. Did you, during that period, take out any patents for dynamo electric machines?

A. Yes, sir.

73 x-Q. About how many?

A. Two, at least; a number of other patents was applied for also before the date named.

74 x-Q. About how many were applied for before 85
the date named relating to dynamo-electric machines?

A. Three or four more, according to the best of my recollection at the present moment.

75 x-Q. Who paid the expenses of those applications and the obtaining of such patents?

A. What may be called the firm of Stevens, Roberts, Havell & Weston; in other words, the patent expenses were paid out of the proceeds of the machine business.

76 x-Q. (Handing paper to witness). Please look at the specification of original patent No. 180,082, dated July 18th, 1876, and state if that is one of the 86
Patents applied for and obtained during that period?

A. Yes, sir.

77 x-Q. (Handing another paper). Please look at the specification of patent No. 182,977, dated October 3d, 1876, and state if that is one of the patents applied for and obtained during that period?

A. Yes, sir.

78 x-Q. You spoke of having experienced a difficulty in winding the armatures of dynamo-electric machines with wire or strips of sufficient thickness to enable you to obtain a very low resistance and low electro motive force. What was the cause of 87
that difficulty?

A. One of the main difficulties is the position of the shaft forming the axis upon which the armature runs; this is particularly noticible in that type of machine which has now become well known and which I distinguish as the sectional armature machine; and furthermore, there was great difficulty in securing the armature to the shaft without the use of brass caps, which rendered the structure mechanically weak and consequently defective; this I had discovered by practical use of the machines built from 1873 up to the year 1875.

79 x-Q. What are the advantages of connecting

88 the longitudinal conductors by end disk connections?

A. The advantages are, first, reduction in the total amount of inefficient wire on the armature; second, decrease in size of the armature; third, increased mechanical strength; fourth, greater efficiency and greater ease in construction. The armature shown and described in the patent No. 180,082 overcame some of these difficulties and answered well in medium sized machines, but in the construction of large machines it does not answer the purpose as well. It will be noticed that in this machine the armature is not wound diametrically
89 across the ends, consequently the shaft passes through the hub to which the core is fastened, and gives the machine great strength. It is also a very cheap machine to build.

80 x-Q. Does patent No. 180,082 represent the form of dynamo electric machine which you were building during the arrangement spoken of with Stevens, Roberts & Havell?

A. It represents one of the forms; not precisely, but only diacritically.

81 x-Q. In what respects, if any, are machines constructed with end disk connections connecting longitudinal conductors an improvement upon the stple of dynamo electric machines referred to in pa-
90 tent No. 180,082?

A. If properly made and proportioned they are more efficient, but they must be built on a larger scale and with much larger field magnets in proportion to the size of the armature than those shown in the drawing to which you refer.

82 x-Q. Why has a machine constructed with end disk connections for longitudinal conductors greater efficiency than other forms of machines?

A. Mainly on account of the disposition of the wire in relation to the field-of-force magnets.

83 x-Q. Why is there greater ease of construction in constructing such a machine—the one with the end disk connections?

A. There is no greater ease; this difference does 91
not exist in the two machines to which you refer, namely: the one described in my patent 180,082, and the machine with end disk connections.

84 x-Q. Why is it easier to construct a machine with end disk connections and longitudinal conductors than other forms of dynamo-electric machines ordinarily made:

A. The shaft can then be passed directly through the centre of the iron core, thus giving the armature great strength in a very simple way. Again, the over-lapping of the wires at the end and the care required in laying the same are avoided.

85 x-Q. Do these facts conduce to the cheapness 92
of the machine?

A. Yes, with a given machine to produce a given result.

86 x-Q. Is there any saving or economy by reason of the use of end-disk connections in place of over-lapping wires at the ends of the armature?

A. Yes, sir.

87 x-Q. About what proportion of saving is there, taking into account the expense of labor of winding the armature with over-lapping wires?

A. I cannot state precisely what the saving or economy would be, but know it would be considerable, for a given machine to produce a given re-
sult. 93

88 x-Q. While you had the arrangement spoken of with Messrs. Stevens, Roberts and Havell, how many sizes of dynamo-electric machines did you build?

A. Only three which were generally sold.

89 x-Q. By what names were they known?

A. Eight, 12 and 16 inch machines.

90 x-Q. Were these machines of the kind described in your patent No. 180,082?

A. Yes, sir.

91 x-Q. Did you during that period construct any machines with over-lapping wires at the ends of the armature?

94 A. Yes, sir; but to the best of my recollection, none of them were sold.

92 x-Q. By what names were those machines known?

A. They had no distinguishing names.

93 x-Q. About how many of such machines did you construct during that period?

A. Possibly three; certainly two.

94 x-Q. How large were those machines?

A. One weighed about 60 or 70 pounds, and the other a little over 200, I should think.

95 x-Q. When did you construct those two machines?

95 A. One in the early part of the year 1879, and one, according to the best of my recollection now, later on.

96 x-Q. Did you construct any such machines during the period prior to July 10th, 1877, up to which date you stated that your arrangement with Messrs. Stevens, Roberts & Havell continued?

A. Yes, sir; the machines to which I refer were built before that time.

97 x-Q. I understood you just now to say that they were built in the year 1879—please explain what seems to be a discrepancy?

A. I must have made a mistake, sir; the machines were built as first stated, namely, in 1879; I
96 can give nearly the exact date by reference to memoranda, which I can obtain.

98 x-Q For whom were those machines built?

A. They were not built for any one in particular, and, to the best of my recollection, neither of them was sold.

99 x-Q. Were they built for sale?

A. No, sir.

100 x-Q. For what purpose were they built?

A. Experimental test.

101 x-Q. In what way did you wind the armatures of the machines which you did sell within the period during which you were with Messrs. Stevens, Roberts & Havell?

A. They were wound in a similar way to that described in my patent No. 180,082. 97

102 x-Q. Were they all wound in that way?

A. To the best of my recollection all machines that we sold for the purpose of electro-plating were. I should like to state here that I make a great distinction between two classes of machines which the counsel does not probably understand; machines for electro-plating purposes are quite different from those for electric-lighting purposes; they differ in regard to the size of the wire employed and the number of convolutions. Taking into consideration those facts the testimony which I have heretofore given in this cross-examination related solely and simply to those machines which were adapted to 98
produce currents suitable for the purpose of electro-plating.

103 x-Q. What are the characteristics of machines for electro-plating?

A. The machines have a lower electro-motive force and are wound with a smaller number of convolutions of wires, bars or strips, so as to reduce the internal resistance of the same.

104 x-Q. Is it very desirable in a dynamo-electric machine for electro-plating that it should have a low internal resistance and low electro-motive force?

A. It is.

105 x-Q. During the period prior to July, 1877, 99
did you make and sell any dynamo-electric machines for any other purpose than for electro-plating?

A. Yes, sir.

106 x Q. For what other purpose?

A. To produce electric light by the voltaic arc method.

107 x-Q. How were the armatures of those machines wound?

A. Some of them were wound with wires overlapping at the ends of the armature.

108 x-Q. How many of the last named machines did you make and sell during that period?

A. I cannot say.

100 109 x-Q. About how many?

A. I don't recollect; I could not even guess at the number.

110 x-Q. Do you think as many as 100?

A. Not so many; I am quite sure of that, but more than one.

111 x-Q What was the change in your business relations which took place on July 10th, 1877?

A. The business was transferred to the Weston Dynamo-Electric Machine Company which was organized on the date named.

112 x Q. What change did that make in your method of conducting business?

101 A. We somewhat increased the scope of our operations.

113 x-Q. How?

A. In various ways; we increased our facilities for manufacturing machines and began to send machines to Europe and other parts of the world very shortly after that time.

114 x-Q. How long did you continue connected with the Weston Dynamo-Electric Machine Company?

A. Until within a short time—I think about July of 1881 or a little later. It would be proper to state here that the name of the company was subsequently changed to the "Weston Electric Light Com-
102 pany," the previous stockholders of the Weston Dynamo-Electric Machine Company still remaining.

115 x-Q. When was the change made to the Weston Electric Light Company?

May 20.80

A. Shortly after the removal of the factory of the company from Washington street to Plane street, Newark, New Jersey. This took place about the month of February, 1880.

116 x-Q. Who were the original organizers of the Weston Dynamo Electric Machine Company?

A. Abraham Van Winkle, George Havell, Hiram P. Baldwin, James Roberts and Edward Weston.

117 x-Q. What was the capital of the company?

A. Nominally $200,000.

118 x-Q. Actually, what?

A. About $12,600 was originally paid in to the treasury of the company, about $10,000 of which 103
purchased the stock, tools, machinery, etc., from the firm of Stevens, Roberts & Havell, and myself.

119 x-Q. What was the business of the Weston Dynamo Electric Machine Company?

A. The construction and sale of dynamo electric machines and apparatus connected therewith.

120 x-Q. Did they construct such dynamo-electric machines, if so, to what extent?

A. They did; they built in all several hundred machines.

121 x-Q. How large was the largest one?

A. Sixteen inches in diameter. It was commonly known as the sixteen inch machine. In 104
other words, the shell to which the magnets were bolted was sixteen inches in diameter.

122 x-Q Please explain a little more fully what you mean by the "shell"?

A. I mean the ring to which the magnets are bolted, as shown by figure 1 in my patent No. 180,082.

123 x-Q. Did the Weston Dynamo-Electric Machine Company construct any other style of machine besides the kind shown in your patent No. 180,082?

A. Yes, sir. 105

124 x Q. How many other different styles?

A. They constructed several machines which I designed for particular purposes; how many I cannot now state without refreshing my memory.

125 x-Q. About how many?

A. Only one which has gone into general use; the others were either designed for some special purpose or were mostly small machines, built in an experimental manner.

126 x-Q. What other style of machine, which has gone into general use, did they make besides the kind shown in your patent No. 180,082?

A. The one which is now well known as the

106 Weston electric light machine, and which has been used to produce the light by the voltaic arc method.

127 x-Q. Is that form of machine described in any patent of yours, if so, what?

A. Yes, it is described in several patents.

128 x-Q. Please name them?

A. I cannot now recollect the numbers and dates exactly, but most of the patents were taken out in the latter part of 1879, or the early part of 1880, and I think one of them is numbered 209,532.

B 209532 was taken out Oct. 29. 1878.

129 x-Q. Did they ever manufacture any machines like this described in your patent No. 201, 968?

107 A. Yes, sir. When you say "manufactured," I should like to substitute the word "construct." There were none manufactured and sold.

130 x-Q. Why not?

A. The machine which is shown in this patent is more expressly designed for furnishing the current suitable for telegraphing, or an alternating current for electric light. At the time named it was supposed that we could get a contract to build such machines for the now well known American Rapid Telegraph Company, and for this purpose I built one or two small machines which I tested. The terms of the proposed agreement, however, did not
108 prove very encouraging, and as the company was not rich by any means, we did not assume any risk, and the matter was allowed to drop.

131 x-Q. Was the machine described in patent No. 201,968 adapted for use for electro-plating?

A. Not well adapted. It might possibly be used for that purpose, but not to advantage.

132 x-Q. Why not?

A. It was more suitable for the production of currents of higher tension than for currents of low tension.

133 x-Q. Why?

A. Because it would have been difficult to have constructed such a machine within the moderate compass of machines used to furnish the current

required for electro-plating. In other words, there 109
were far better machines for this purpose than the one to which you refer.

134 x-Q. What were the peculiarities of construction of this machine described in your patent 201,-968 which rendered it unsuitable for use for electro-plating?

A. First, the size of the rotating magnet would have had to be enormously increased to furnish a machine such as you speak of. This would, of course, increase the cost of the machine. Second, the arrangement of the commutator brushes and commutator connections were too complicated to put in the hands of men unfamiliar as electro-platers generally
are with the principles involved in the construction 110
and operation of such machines. Again, great difficulty would have been experienced in winding the rotating magnets with strips or wire of such size as are required to conduct the currents used in the art of electro-plating. These peculiarities arising from the design of the machine would, in my opinion, have rendered it entirely unfit for the purpose named. On the contrary, it would suit the purpose for which is was intended admirably, because there is no great difficulty in winding such thin wires on such a machine as would be required for the purpose of furnishing the feeble current for telegraph-
ing. 111

135 x-Q. Was the machine manufactured by your company and described in your patent No. 209,532 adapted for electro-plating?

A. Yes, if wound with copper bars connected at their ends by a disk, and to the commutator strips in a manner identical with that described in the patent. This, however, would necessitate the bearing at the commutator end being placed in a different position from that shown in the drawing of the patent to which you refer. A small machine might be built exactly in the manner shown there, suitable for the purpose to which you refer, but it would have to be very small.

112 136 x-Q. Would a machine constructed as shown in Patent No. 209,532, if the armature were wound with copper bars connected at their ends by a disk, be suitable for an electric light machine?

A. Yes, if made large enough to furnish the required electro-motive force and the position of the bearings were changed in accordance with the requirements, so that a person could connect the strips of the commutator to the loops or bars on the armature. I will state here, however, that no such machines have ever been called for until quite recently, as such large arc lights have never been (to my knowledge, at any rate) used or required.

113 137 x-Q. Would a machine constructed like that described in patent No. 209,532, except that the armature was wound with copper bars, connected at their ends by a disk, have any advantage in economy of manufacture or efficiency, as compared with the machine specifically described and illustrated in said patent No. 209,532?

A. That would depend entirely upon the use to which the machine was to be put. If it were to be used for an arc light such as we generally use to day, I answer no. If, on the contrary, the machine were to be used for furnishing currents of great volume and low tension, then it would have advantages in economy of construction and efficiency.

114 138 x-Q. Was there any purpose or use for which your company—the Weston Dynamo-Electric Machine Company—manufactured dynamo electric machines for which a machine constructed as referred to in the last question would have any advantage, either in economy or efficiency, over that specifically described in patent No. 209,532?

A. Yes.

139 x-Q. For what purposes and uses?

A. It would have been much more efficient, if wound in the manner described, in the use of the machine on a very large scale for the purpose of depositing metals from their solutions.

140 x-Q. What do you mean by "a very large 115
scale?"

A. A scale much beyond the ordinary requirements of the electro-plating and electrotyping trade in general.

141 x-Q. Do you mean much beyond the requirements of any machine which your company constructed?

A. Practically, yes.

142 x-Q. Please explain a little more fully what you mean by the word *practically* in your last answer?

A. I mean to say that the average electro-plater, did not require machines any larger than we were 116
then building and which were constructed in the usual manner. I mean also to say that there were some people who could have afforded, possibly, to pay for such machines as you have described, while others could not. The number of users of such machines, however, would have been, at the date of the patent particularly, very limited.

143 x-Q. Did your company ever manufacture any machines for sale with the armature wound with copper bars connected at their ends by a disk or disks?

A. No, sir.

144 x-Q. Did the Weston Electric Light Company ever manufacture any such machines for sale? 117

A. No, sir.

145 x-Q. Did either of the said companies ever manufacture any such machine which has ever been put to any business use?

A. May I ask what you mean by *business use?*

146 x-Q. I mean anything beyond a mere test or experiment?

A. No, sir.

147 x-Q. In your direct evidence you referred to certain large drawings which are dated October, 1879, and have been marked "Exhibit Weston No. 5," sheets 1 to 6, inclusive. Was the machine referred to in said drawings ever completed?

See fol. 42

118 A. No, sir. 5

~~148 x-Q.~~ Is the use of end disks on an armature of any utility in machines having high electromotive force?

A. It depends upon the size of the machines. It would have had no practical utility up to within a very recent period.

149 x-Q. Would such disks have had any utility in point of economy of manufacture on any machines of high electro-motive force of the sizes which your companies manufactured?

A. Not until within a very recent period. In other
words, there was no demand for such large ma-
119 chines as would call for this modification in the
winding of the machine described.

150 x-Q. Would the use of end-disks connecting copper bars on the armature increase the efficiency of a machine of the size indicated by your exhibit No. 4?

A. Not if built for the purpose for which it was originally intended, namely: the production of a series of arc lights. On the contrary, if built for the purpose of electro-plating or electrotyping on a large scale, then it would have had an advantage in point of efficiency and economy of construction. I
wish to say, however, that it is difficult to draw
120 these comparisons between such widely different
qualities of current, without a more definite statement of the purposes for which the machine is intended. In other words, the machine to which you have referred was originally designed to furnish a current of about 20 webers through a very high resistance; whereas, if constructed in the manner you have described, namely: with copper disks and bars, and as shown in the drawings Exhibit No. 5, it would have furnished a current of several hundred webers through a comparatively low resistance. From this it will be seen that it is very difficult for me to state precisely where the points of efficiency and economy of construction would come in between these two, substantially, similar ma-

chines, namely: the one described in the patent No. 121
209,532, and the one shown in the drawings to which I have referred.

151 x-Q. You speak of the machine, of which your Exhibit No. 4 was the armature, having been originally designed for furnishing a current for electric light. Did you ever make or sell any machines of that size and construction for any other purpose, and if so, what purpose?

A. No, sir.

152 x-Q. You spoke of having built a machine in 1877 almost identical with the one which you built in 1875, and which had two circuits and two commutators. For what purpose did you build that ma-
chine with two circuits and two commutators? 122

A. Practically for the purpose of electro-plating and electrotyping.

153 x-Q. Did you build it for any person, or merely for an experiment of your own?

A. It was not built for any particular person, and was used practically only by myself.

154 x-Q. How came you to make this experiment of 1877?

A. The machine was mainly designed for supplying different qualities of current for the different solutions with which we came in contact.

155 x-Q. What were the characteristics of the ma-
chine which fitted it for the purpose for which you 123
say it was mainly designed?

A. The use of two commutators with four brushes practically gave us the power of obtaining three different qualities of current; by connecting the brushes in series the machine would have just double the electro motive force of where the brushes were only connected to one commutator; and by connecting the brushes in multiple arc it was possible to obtain a current of half the electro motive force and the resistance of the remainder would be reduced to one-fourth the previous resistance. Or, again: It was possible to run two independent circuits from the machine; thus giving an electro-

124 plater a wide margin, to suit his different solutions.

156 x-Q. Did you or your company ever build for sale any of these machines with two circuits and two commutators?

A. No, sir.

157 x-Q. How do you fix the time when you made this machine of which you have spoken with two circuits and two commutators?

A. From the fact that it was about the time that negotiations first commenced in relation to the formation of the Weston Dynamo-Electric Machine Company, and that very shortly after this—some time in the latter part of May, I went down to
125 Washington.

158 x-Q. What connection is there in your mind between the negotiations for the formation of the Weston Dynamo-Electric Machine Company and the making of this machine?

A. Nothing further than what I have previously stated, and the fact that I thought of applying for a patent for the same about the time named, and believe I described the same to my patent attorneys in Washington; the dates, however, are quite clear in my own mind, from these circumstances.

159 x-Q. Do you associate in your own mind the making of this machine in any way with the formation of the Weston Dynamo-Electric Machine Com-
126 pany?

A. Yes.

160 x-Q. How?

A. More particularly, I think, because at the time named I described the machine and its peculiarities, and the prospects of the business, in a little dispute which arose between Mr. Roberts, Mr. Havell and myself in relation to the formation of a company. My ideas in regard to the business did not agree with theirs; Mr. Stevens having withdrawn, they were somewhat opposed to dividing the interests and organizing the business on a better basis. I placed before them the facts relating to the possible enlargement of the business, and its being be-

yond their means to carry out some of the ideas 127
which I had. This and several other circumstances, including the visit to Washington, enables me to fix the date very closely.

161 x-Q. Was this the only machine which you described to Messrs. Roberts & Havell at the time?

A. No; I distinctly recollect enlarging upon the future prospects of the business, both in electroplating and in electric lighting, and in other branches.

162 x-Q. Did this dispute have anything to do with the machine with two circuits and two commutators?

A. Nothing more than that I illustrated my mean- 128
ing in relation to the manner of conducting the business, by pointing out the fact that we were not developing the business as we ought to do, and that we had but few facilities for advancing in any of the lines which I laid out.

163 x Q. What other lines had you laid out?

A. I enlarged upon the possibility of building machines for numerous purposes for which they were not then used, and of designing machines better adapted for the work which we were then doing. I also spoke particularly about the desirability of patenting all new devices as fast as they originated. I particularly urged upon them the importance of the
use of special machines for telegraphing, electric 129
light, electric brakes, the transmission of power to a distance, and even for other uses, such as rock drilling by electricity, of which I had a rough model drill made. I hoped in this way to secure their approval of the formation of a company, and at the same time gain the necessary means to carry on the development of the business.

164 x-Q. Did you by these arguments of yours secure the approval of Messrs. Roberts & Havell for the formation of a company?

A. Not until I had become somewhat exasperated at what I considered their too narrow views, and positively told them that I should be obliged to de-

130 vote my attention to something which looked a little more promising in a pecuniary sense.

165 x-Q. Did you then secure their approval?

A. I did; and the result was the formation of a company which commenced operations on June 1st, but did not organize properly until July the 10th of the year named.

166 x-Q. What is the connection between your trip to Washington and this machine of which you have spoken, with two circuits and two commutators?

A. I took some models with me to Washington, to apply for a patent, and also went down to assist
131 at the reissue of the patent No. 180,082. All these things are so correlated to each other as to fix the date in my own mind beyond a doubt.

167 x-Q. Did you apply for a patent for the machine with the two circuits and two commutators?

A. No; neither were the other cases, except the reissue, pushed; and from that day to this no patents have been obtained, although I have quite recently applied for patents on some of the devices, models of which I then took with me to Washington.

168 x-Q. Did you take with you to Washington, at that time, any model of the machine with two circuits and two commutators?

132 A. I think not.

169 x-Q. Who was the attorney who acted for you and the company at that time?

A. Messrs. Roberts & Havell's attorneys, namely: Alexander & Mason of Washington.

170 x-Q. On your direct examination you produced a part of a machine marked Exhibit No. 3, which consists in part of a copper cylinder closed at one end, except for the shaft hole, and open at the other. Where was that copper cylinder made?

A. It was made partly in the shop of the Weston Dynamo-Electric Machine Company and partly in my laboratory.

171 x-Q. Where was the shop of the Weston Dy- 133
namo Electric Machine Company at that time?

A. 286 Washington street, Newark, New Jersey.

172 x-Q. Prior to making said copper cylinder had you ever known of the use of any similar copper cylinder in any dynamo-electric machine?

A. No, sir.

173 x-Q. How came you to adopt that form of device?

A. From theoretical considerations only.

174 x-Q. What was your theory which led you to adopt that form of construction?

A. The theory upon which dynamo electric machines in general are based, namely: that a con- 134
ductor moving at right angles to the lines of force of an electro-magnet will generate a current. Assuming from this—which was my prior experience—that you may look upon a cylindrical armature with wires on its periphery as a series of sections of a cylinder, I had the armature which you have described constructed.

175 x Q. How long prior to the construction of the armature marked Exhibit No. 3 did you come to that conclusion?

A. I cannot say.

176 x-Q. Can you give us any idea when you first thought of it?

A. I cannot; but it was, no doubt, very shortly 135
before the construction of the cylinder in its present form.

177 x-Q. Did you have more than one of the said copper cylinders constructed at the same time?

A. No.

178 x-Q. Did you make any more subsequently?

A. No

179 x-Q. Why not?

A. Because I saw that it would require a very large machine to give the necessary electro motive force for the purposes for which the machine was intended.

180 x-Q. Did you about the time of constructing

136 the armature marked Weston Exhibit No. 3 construct any other machines at all resembling it?

A. Yes, and ordered copper about this time for the bars and disks to be used in winding one of our large machines for the purpose of the electro-deposition of metals from their solutions in the manner described in my application for the patent in issue in this interference.

181 x-Q. You say you ordered copper for the copper bars and disks to be used in winding one of your large machines. Did you ever so wind said large machine?

A. No; for the reasons already stated in my
137 direct examination.

182 x-Q. How did the other machines you constructed about this time, which at all resembled the one of which the armature Exhibit No. 3 is a part, differ from such last mentioned machine?

A. I presume you mean by "last mentioned machine" the Armature Exhibit No. 3?

183 x-Q. I do?

A. Then in the only other machine which I built which resembled it almost exactly, in princple, and somewhat in mechanical construction, the wires were connected to a disk at one end and to the commutator strips at the other. In other words, the
138 wires may be looked upon as radial arms extending from the brass or copper disk, and bent over so as to envelope the armature; the other or free ends were then conducted to the commutator strips. In this case the wires were all connected in multiple arc by the brushes which press on the respective strips of the commutator, so that the wires may be looked upon, and were, practically, sections of a cylinder similar to that in Exhibit No. 3.

184 x-Q. Was the disk a brass disk or a copper disk?

A. To the best of my recollection it was a brass disk of a considerable cross-section, and consequently very low resistance.

185 x-Q. How thick a cross-section?

A. About a quarter of an inch. 139

186 x-Q. How did it compare in size and diameter with the armature?

A. Nearly the same.

187 x-Q. Not as large?

A. Very little smaller indeed.

188 x-Q. How much smaller?

A. Possibly half an inch in diameter.

189 x-Q. How many wires were there which were bent over from this disk on to the sides of the armature?

A. There were, to the best of my recollection, sixteen independent wires.

190 x-Q. All attached to the same brass disk? 140

A. All attached to the same brass disk at one end and to the commutator strips at the other. The commutator strips in this machine had an helical curve corresponding nearly to one-half of the cylinder to which they were attached, so that the brushes which were placed on opposite sides of the wire pressed on all but two of the commutator strips, thus connecting them in multiple arc, substantially as in the cylinder, Exhibit No. 3.

191 x-Q. What was the material of these wires?

A. Copper.

192 x-Q. Of what size?

A. I should say about 1-16 or 1-17 of an inch in
diameter. 141

193 x-Q. Do you remember the guage?

A. The guage corresponded very nearly with the dimensions already given, namely, 16 or 17.

194 x-Q. Where was the wire placed with reference to the bearings in the machine of which Weston Exhibit No. 3 was the armature?

A. The end of the cylinder was the commutator in this case. The end of the copper cylinder which projects out beyond the end of the iron cylinder. In other words, in this machine no commutator was required; and in all machines the commutator is simply a prolongation of the end of the conductor, generally made for convenient removal in case of

142 an accident to the machine, or in case it required repairs either from continued use or from any other cause.

195 x-Q. Where was the commutator in the other machine of which you have spoken, which you made about the same time as Exhibit No. 3, which had a brass disk and wires bent over the sides of the armature?

A. The commutator was outside of the bearings at the end opposite the pulley.

196 x-Q. Were these two machines, the one with the brass disk and the one with the copper cylinder, Exhibit No. 3, made at the same time, if not, which was made first?

143 A. To the best of my recollection the one with the brass disk was made first.

197 x Q. How long an interval was there between the making of the two?

A. Very little; probably less than a week.

198 x-Q. How do you fix the time when you made these two machines?

A. I fix the time by the date of the order for the copper bars to which I have already referred?

199 x-Q. Where do you find said order?

A. On the books of Messrs. Staniar & Laffey, of East Newark.

200 x-Q. Were those bars ever furnished?

144 A. No, sir

201 x-Q. Did Messrs. Staniar & Laffey ever furnish any copper sheets for disks?

A. No, sir.

202 x-Q. Which of the two machines, the one with the copper cylinder, Exhibit No. 3, or the one with the brass disk, was it which you tested at the plating-shop of Messrs. Roberts and Havell?

A. You misunderstood the answer to the question from which you take your information, and on which you base your question. According to the best of my recollection neither of these two machines was used at the shops of Messrs. Roberts & Havell, but the machine in which the wires and

copper disks were connected in series and not in 145
multiple arc, as are the two machines to which you have referred.

203 x-Q. Were either of said machines—the one with copper cylinder, or the one with the brass disk, tested at all?

A. Yes, sir.

204 x-Q. Where were they tested?

A. In the shop of the Weston Dynamo-Electric Machine Company, and in my laboratory.

205 x-Q. How early did you ever know of the use of bars as the winding of an armature of a dynamo-electric machine as distinguished from wires?

A. With bars or strips, or in other words, very 146
large, flat bars; they were known to me as early as 1867, as a mode of winding for a dynamo-electric machine armature.

206 x-Q. How were such bars or strips connected at the ends of the armature?

A. They overlapped.

207 x-Q. Whom did you know of using such bars or strips in 1867?

A. Mr. Wilde of Manchester, England.

208 x-Q. Did you know of the Siemens plating machine constructed of bars about the armatures?

A. If you will be kind enough to state what you mean when you speak of the Siemens machine, I
shall be able to answer the question, I think. 147

209 x-Q. Did you know of any machine constructed by Siemens with those characteristics?

A. No, I did not, until a recent period.

210 x-Q. You have spoken of your company having constructed a number of dynamo-electric machines for special purposes. For what purposes have such machines been constructed by your company, other than electro-plating and electric light?

A. For furnishing a current of electricity for an automatic stop action for silk looms, for electric brakes, for decomposing water, and other similar purposes, all of which I cannot now recollect.

148 211 x-Q. Were the machines of high electro motive force, or low electro motive force?

A. Medium electro motive force, and generally small machines.

212 x-Q. For whom did you construct such machines?

A. For the Springfield Silk Company, I think is the name of one of the concerns, the New York Electric Brake Company, and other parties whose names I cannot now recollect. In fact, quite frequently the orders for special machines came through agents, who simply stated the purposes for which they were desired.

149 Adjourned to Tuesday, Feb. 14th, at 11 A.M.

Feby. 14th, 1882.

Met pursuant to adjournment.

Present—

Counsel for the respective parties as before.

Cross-examination of EDWARD WESTON continued by Mr. Betts:

213 x-Q. Please describe the first dynamo-electric machine which you commenced to construct after
150 you made your arrangement with Messrs. Stevens, Roberts & Havell, which you say was in 1875?

A. I find some difficulty in fixing upon the first machine which I commenced to build at that time, having built several. I cannot now recollect the exact order in which they were commenced.

214 x-Q. Can you recollect the first dynamo-electric machine which you then undertook to build, commercially?

A. Yes, sir; the machine similar to the machine described in my patent, No. 180,082.

215 x-Q. Was the winding of the armature of that first commercial dynamo-electric machine which you then undertook to build, like that described in your patent No. 180,082?

A. Substantially the same as that described in 151
the patent.

216 x-Q. How long did you continue to build machines of that class before you undertook to build any other commercial dynamo-electric machine?

A. Until about the latter part of the year 1876, or the early part of the year 1877, according to my recollection at the present moment, without refreshing my memory by reference to papers and other things that may enable me to fix the date more accurately. I do not wish to be understood, however, that these machines were sold at the time, as we found some difficulty in selling
the class of machines to which I refer, in the earlier 152
stages of the business.

217 x-Q. When *did* you first commence to sell any machines constructed as described in your patent, No. 180,082?

A. Possibly as early as December, 1875; may be a little earlier.

218 x-Q. Had you, previous to the building of those machines described in your patent, No. 180,082, undertaken to build any other form of commercial dynamo-electric machine?

A. Yes, sir; the first machine I built was built in the latter part of 1872, or the early part of 1873. In this machine the wires overlapped at the ends.
When I stated in my answer to your 48th cross- 153
interrogatory the time when I first experienced the difficulty referred to therein, by a lapse of memory I neglected to mention these earlier machines. I also built machines in 1874, having the same general features, namely: the wire overlapping at the ends of the armature, and was thoroughly acquainted at that time with the mechanical difficulties of the construction of such armatures, so as to understand the strain to which they were exposed in every day use. I had gained this knowledge and experience from the use of the first machine which I built in 1873 and 1874.

219 x-Q. Had you, previous to building the ma-

154 chine described in your patent 180,082, and after your arrangement with Messrs. Stevens, Roberts & Havell, undertaken to build any other form of commercial dynamo-electric machine ?

A. Understanding by the term "commercial" that you mean machines for sale, I answer, no.

220 x-Q. How long were you in experimenting upon the machine described in your patent 180,082 before you produced said machine ?

A. I cannot state the exact time, but can furnish you with the information upon consultation with Messrs. Roberts & Havell and a reference to their books; it was, however, several months.

155 221 x-Q. In your first experimental machine with an end-disk connection, what was the material of the disk ?

A. Copper.

222 x-Q. What was the size of the disk ?

A. I should think 4½ to 5 inches in diameter; might have been a little more or a little less; I cannot now recollect with certainty.

223 x-Q. What was the thickness of the copper ?

A. About one-eighth of an inch, more or less.

224 x-Q. With what was the armature wound ?

A. No. 12 wire, I think, originally.

225 x-Q. What was the diamater of the armature ?

156 A. About the same as the copper disk.

226 x-Q. Was it larger or smaller than the copper disk ?

A. A trifle smaller.

227 x-Q. Of what material was it made ?

A. Iron rings, with a wooden cylinder; and the rings were separated from each other by a washer of paper.

228 x-Q. How was the No. 12 wire attached to the disk ?

A. Soldered.

229 x-Q. How many wires did you use ?

A. I do not recollect exactly, but quite a large number.

230 x-Q. *About* how many ? 157

A. A number nearly sufficient to enclose the entire armature.

231 x-Q. Were said wires separate or connected together ?

A. What do you mean by "connected together"?

232 x-Q. Were they together in any way except by being connected to the disk ?

A. Yes, sir; they were connected to the commutator strips which were fastened to a wooden hub at the end of the shaft opposite to the copper disk.

233 x-Q. Were these wires bare or insulated ?

A. Insulated with cotton

234 x-Q. How many commutator strips were there ? 158

A. I cannot now state, but quite a large number.

235 x-Q. Where did you buy the copper to make the disks of ?

A According to the best of my recollection Mr. Havell bought the copper, and I believe he went to Messrs. Hendricks, the copper manufacturers, to get the same.

236 x-Q. Can you state the internal resistance of that machine ?

A. No, sir, I cannot; I had no apparatus at the time which would measure so low a resistance as the armature had. 159

237 x-Q. How many field magnets were there in the machine ?

A. One.

238 x-Q. Give the dimensions of that ?

A. I think the bars were half an inch thick, probably a little less, and from four to six inches wide.

239 x-Q. And what was the length ?

A. The length from end to end, from 8 to 10 inches.

240 x-Q. What was the size of the wire used on the field magnets ?

A. About the same as on the armature.

160 241 x-Q. You say "*about* the same." What do you mean by that?

A. I think there was very little difference. In fact, I think the two wires—or two sets of wires—were cut from the same roll.

242 x-Q. Were the iron rings used by you cast or wrought iron?

A. Wrought iron.

243 x-Q. How thick were they?

A. About an eighth of an inch.

244 x-Q. Where did you procure them?

A. From Messrs. Roberts & Havell. In fact, according to the best of my recollection, Mr. Havell
161 brought the rings, himself, to New York.

245 x-Q. Were you using any such rings for any other purpose?

A. No, sir; although I subsequently used them for some other purpose.

246 x-Q. What other purpose did you subsequently use them for?

A. Possibly in a different arrangement of the machines.

247 x-Q. In what machines?

A. Machines having the same general features, so far as the sectional armature was concerned.

248 x-Q. When did you first commence to make machines with sectional armatures?

162 A. As early as 1873 or '4.

249 x-Q. Was there anything to distinguish the rings which you say you used on the first experimental machine with the end-disk, from the rings used on other machines with sectional armatures?

A. Yes, sir; the armatures made with the previous machines which had been built—sectional armatures—were made of cast iron, and the core differed very materially in shape; one of this latter shape of machines was used by me for quite some time in my plating business in New York, but not in a public manner.

250 x-Q. How did the iron rings of your previous machine compare in thickness with the iron rings

you used on the first experimental machine with 163
the end-disk?

A. The core of the first named form of armature was not in the form of a ring; the cross sections of the core, however, were much larger.

251 x-Q. Do you mean by *larger*, thicker?

A. Yes, I mean the iron between the space or split of the cross section.

252 x-Q. Were the rings separated from each other by spaces or any insulated material in said first experimental machine?

A. By an air space. It is scarcely proper, however, to call these *rings*, although the armature was
cylindrical in form. 164

253 x-Q. Why?

A. Because looking at the armature from the centre and imagining it to be split in two, the cross-section of the core did not correspond with the shape named.

254 x-Q. How was the copper disk of this experimental machine attached to the armature?

A. Simply slipped over the shaft and insulated therefrom, with wires to keep it in place. The wires were either covered with bands of fine twine or very fine wire; I think fine wire, to prevent their being thrown outward by centrifugal force when the machine was run.

255 x Q. How was the disk insulated from the 165
shaft?

A. By wood.

256 x-Q. Please describe more particularly the wood insulation?

A. The central core of wood was turned down, or a simple tube of wood was slipped over the shaft; I think the former was the kind of construction adopted.

257 x-Q. Did anybody assist you in making this machine?

A. I cannot say positively whether any one assisted me in making it, but they certainly assisted me in running it, by a belt from a foot-lathe.

166 258 x-Q. Who so assisted you?

A. Mr. John Gormley.

259 x-Q. Was the machine ever run except by a belt and foot-lathe?

A. Yes, sir.

260 x-Q. How much power do you think was required to run the machine?

A. I do not know, as they were not in the habit of measuring how much power was required to run a machine in those days.

261 x-Q. Can you form any estimate of it now?

A. No; but I know it was pretty hard work to turn it by a foot lathe.

167 262 x-Q. Was there any shafting running through your laboratory at that time?

A. No, sir.

262 x-Q. Please describe specifically how you connected the wires with which the armature was surrounded, in this first experimental machine, to the commutator?

A. They were soldered to the respective strips, as was quite common in those days, and as is still quite commonly the case.

264 x-Q. How were the iron rings secured to the wooden case?

A. By tapering pins driven into the periphery of the wooden case.

168 265 x Q. What kind of wood was the case made of?

A. Pine, I think.

266 x-Q. What was the field magnet made of, wrought iron or cast iron?

A. Wrought iron.

267 x-Q. Was it made specially for that purpose, or did you have it before?

A. Yes, sir, made specially for this purpose.

268 x-Q. By whom?

A. Some of the workmen of Messrs. Stevens, Roberts & Havell, whom I cannot state.

269 x-Q. Were the wires which surrounded the armature and which were fastened to the disk soldered at the edge of the disk or on the face of the disk? 169

A. At the outer face of the disk.

270 x-Q. In figure 1 of the drawing, Weston Exhibit No. 1, what are the radial marks which appear on the end of the armature?

A. Prolongations of the wire on the core leading to the commutator strips.

271 x-Q. Does figure 1 represent the commutator end of the machine?

A. Yes, sir—the commutator side, more properly speaking.

272 x-Q. Where, with reference to the bearings of said machine, was the commutator?

A. Inside the bearings. 170

273 x-Q. Was this machine made from any drawing?

A. Sketches were no doubt given for at least the measurements for the construction of the mechanical part.

274 x-Q. Do you remember whether sketches were given, or only dimensions?

A. Both, I think.

275 x-Q. Who made such sketches?

A. Undoubtedly they were made by me.

276 x Q. Do you remember making any such, or do you merely speak of the probabilites of the case?

A. More of the probabilites of the case, and from the usual plan of working at that time. 171

277 x-Q. Do you suppose that any working drawings were made of said machine?

A. No; I had no draftsman at the time.

278 x-Q. Did you consider the form of winding the armature embodied in your first experimental machine with end disks as contributing to the cheapness of the machine?

A. Yes.

279 x-Q. Would a machine constructed as decribed in your application in interference in this case be a cheap form of machine to construct?

172 A. Not as cheap as the machine shown in the patent No. 180,082.

280 x-Q. Why do you think it would be more expensive than that?

A. First: partly on account of the mechanical construction of the same, and, second, on account of the difference in the material to produce a given result.

281 x-Q. What features of the mechanical construction would render it less cheap than the machine shown in your patent, 180,082?

A. The construction of the armature with wrought iron disk would greatly enhance the cost
173 both in material and labor of such a machine. Again, the form of commutator employed in the patent 180,082 is extremely easy to make and replace or repair when worn. Again, nearly all the work on the machine shown in the patent No. 180,082 can be done in a lathe, by which we are able to secure greater accuracy in construction with much less skilled labor, and consequently supply the machines at a much lower rate.

282 x-Q. Please compare the method of winding the armature described in your patent No. 180,082 with the form of winding embodied in your application now in interference, and state which form of winding would be the cheapest?

174 A. The one shown in the Patent No. 180,082; in the machine as actually constructed each separate magnet and armature is detachable from the hub or shell to which it is finally fixed when wound; this enables you to wind the parts of the machine in a lathe or winding machine; whereas, on the contrary, with the other type of machine to which you refer, the winding of the armature has to be done entirely by hand, and it is impossible to do it by machinery. It is only by considerable practice that persons become sufficiently expert in winding this latter class of armature to produce satisfactory results every time. For instance: it is much easier to secure an equal balance of the armature and an equal distri-

bution around the armature in the machine shown 175
and described in the Patent No. 180,082 than in the other machine, and it is nearly impossible for the operator to get the wire misplaced in the former machine, the shape of the armature practically preventing it.

283 x-Q. What led you to build a machine with two circuits and two commutators, which you stated in answer to the third question, you made in 1877?

A. I have already answered this question in a very full manner.

284 x-Q. Were you led to build this machine by
reason of any defects in your previous machines? 176

A. In a certain sense, yes.

285 x-Q. What were such defects?

A. As already stated, lack of efficiency, and secondly, overheating of the armature particularly in large machines.

286 x-Q. Would the method of winding the armature by longitudinal conductors connected by end-disks tend to prevent the machine from overheating?

A. Certainly.

287 x-Q. Did you have much difficulty due to the overheating of your machines?

A. Some.

288 x-Q. Did you adopt in connection with said 177
machines any device for remedying that difficulty?

A. Yes.

289 x-Q. What was such device?

A. The passage of a stream of water through spaces in the core of the electro-magnets.

290 x-Q. When did you first adopt that device?

A. I cannot state without refreshing my memory in relation to the matter, but think it was early in 1877.

291 Q. When was it, with reference to the time of the making of the machine with two circuits and two commutators which you spoke of as having made in 1877?

178 A. As far as I can now recollect, before that time.

292 x-Q. Are you sure of that?

A. I feel quite sure of it.

293 x-Q. Was the device which you adopted for preventing the overheating of your machines by the use of a stream of water entirely satisfactory?

A. No.

294 x-Q. Why not?

A. Because it was only used to remove the heat generated and not to prevent its generation.

295 x-Q. Did you ever construct any more machines after the first one which had two circuits and two commutators and which were substantially
179 like such first machine?

A. No, but I constructed a machine having two circuits without two commutators, having similar general features.

296 x-Q. When you took up the subject again in the early part of the year 1879, as stated by you in your answer to the third question, "and constructed several machines," what was the construction of those several machines?

A. According to the best of my recollection the machine last described was the first—I am not, however, very positive on this point.

297 x-Q. Which machine do you refer to when you speak of "the machine last described"?

180 A. The machine with the brass end-disk connection referred to in my last answer and already referred to in previous answers during this cross-examination.

298 x-Q. Do you mean that the machine spoken of by you yesterday with a brass end-disk a little smaller than the diameter of the armature was the first one that you constructed in 1879?

A. That is the machine I mean, but I cannot say positively that it was the first one constructed.

299 x-Q. What led you to construct that machine?

A. Views similar to the ones already advanced in relation to the other form of machine with the two end-disk connections.

300 x-Q. What views do you mean—the view of 181
making a machine which would not overheat?

A. Yes, for one thing; and having the capacity of producing currents of widely different quality.

301 x-Q. Did you ever test the machine with the brass end-disk?

A. Yes, sir.

302 x-Q. When?

A. It was no doubt tested immediately after its completion.

303 x-Q. Do you remember testing it?

A. Yes.

304 x-Q. How did you test it?

A. In the usual way, by passing the current
through a galvanometer and by heating the wire. 182

305 x-Q. What were the results of such tests?

A. Quite satisfactory.

306 x-Q. Won't you give the results in detail, so far as you remember them, of such tests of said machine with the brass end disk?

A. I cannot recollect the results in detail; I have no notes of the trial, and am unable to answer your question; I recollect my general impression in regard to the matter quite well.

307 x-Q. Could you give the results in detail of tests of any machines of which you spoke in your direct examination?

A. No doubt I could by endeavoring to refresh 183
my memory in relation to the same.

308 x-Q. Can you do so now?

A. No, sir; only a general impression in relation to the performance of such machines.

309 x-Q. All you ceuld say in regard to any of the tests is that your general impression is that they were satisfactory?

A. No. I could say a little more than that of some of them.

310 x-Q. Was this machine with the brass end-disk tested in Roberts & Havell's shop?

A. I think not.

311 x-Q. What more can you say in regard to

184 the results of any of the tests of machines of which you spoke in your direct examination, except to give your general impression that such tests were satisfactory?

A. I can say, as a matter of fact, that all those machines were built on a correct principle, and would necessarily perform satisfactorily if properly constructed.

312 x-Q. Can you say anything more than that?

A. Yes, I can say that I considered all of the machines good machines.

313 x-Q. Can you say anything more specific than that?

185 A. I have nothing further to add at present bearing upon the matter in question.

314 x-Q. What induced you to make the machine with the copper cylinder, a portion of which was put in evidence, and marked Weston Exhibit, No. 3?

A. Merely with an idea of getting rid of the commutator on machines, and getting the machines of extremely low internal resistance, and of sufficient electro motive force for the purpose of depositing metals from their solutions. I would like to state here, however, that instructions were given at the time to have that cylinder split longitudinally, at about the time it was constructed.

186 315 x-Q. Why was it not split longitudinally?

A. Most likely because I decided that the machine with the conductors connected to the end-disk in series was preferable to the one with the conductors connected to the end-disk in multiple arc.

316 x-Q. You say it was most likely the cause. Don't you remember why it was not split?

A. No, nothing further than that I told my assistant to split it, and it was not split; and I have no doubt this was the main reason.

317 x-Q. Would it have been an advantage to get rid of the commutator?

A. Most certainly.

318 x-Q. Did you subsequently build any machines in which you did get rid of the commutator? 187

A. No.

319 x-Q. During the existence of the Weston Dynamo-Electric Machine Company was the firm of Roberts & Havell engaged in the nickel plating business?

A. Yes; that is, they nickel plated their own work.

320 x-Q. To what extent were they so engaged?

A. Quite largely.

321 x-Q. Where was their nickel plating shop, with reference to the factory of the Weston Dynamo Electric Machine Company? 188

A. About 40 feet from it, in a horizontal line; possibly a little more, and up one flight of steps.

322 x-Q. Can you give, approximately, a statement of how much money you expended experimenting with dynamo-electric machines between the years 1875 and 1881?

A. No, sir.

323 x-Q. State the minimum amount?

A. I cannot state any amount, and would not, if I could. I am prepared to state, however, from general information, that it was much less than Mr. Edison spent in the construction of one large machine, in which he has availed himself of much 189 of the result of the labors of others in this direction.

Objected to as volunteering and not responsive.

324 x-Q. When did you commence to spend anything on dynamo-electric machines made expressly for electric lighting?

A. I shall not answer the question; I am not bound, as I understand it, to furnish information relating to matters which have nothing to do with this case.

190 325 x-Q. Who was foreman of your shop in the year 1877?

A. Practically myself; things were all under my direction, under the approval of the Board of Directors.

326 x-Q. Did anybody assist you in making the machines you spoke of having made in 1877, and which you said had two commutators, if so, whom?

A. Yes, some of the winders who were regularly employed there, no doubt did some of the work on it.

327 x Q. Do you know who they were?

A. I cannot at this moment say who they were.

191 328 x-Q. Do you know of anybody who assisted you in making any tests of said machine?

A. I know some one did assist me.

329 x-Q. Who was it?

A. Probably two or three men or boys at various times.

330 x-Q. Do you know who any of them were?

A. I think so.

331 x-Q. Who were they?

A. I think it is very likely that Mr. Stevens assisted me; also Mr. Otto Hubel.

332 x-Q. Do you know of anybody else?

A. I do not recollect specifically who else assisted me; but it was my custom to call upon anyone who
192 had the least to do, to give me help in such directions.

333 x-Q. Do you know what power was required to drive the machine which you spoke of having made in 1877?

A. No; I do know, however, that, from theoretical considerations, it would be less than in our ordinary machines, which are described in patent No. 180,082.

334 x-Q. Do you know how much power would be necessary to drive the machine which you spoke of having made in the early part of 1879?

A. Yes, sir, approximately; there having been no accurate measurements.

335 x-Q. How much? 193

A. Not less than one-sixth of a horse power, if driven up to somewhere near their capacity.

336 x-Q. Which form of machine would be most economical to run, one constructed according to your patent No. 180,082, or one constructed according to the application now in interference?

A. The latter form, to produce a given result; particularly on large machines. I understand your question to relate to power only.

337 x-Q. Would it be true of all sizes of machines?

A. Yes; but less true on small than on large.

338 x-Q. What saving would there be in power
by the use of the machine wound as described in 194
your application now in interference, as compared with one constructed according to your patent No. 180,082?

A. There might be none at all, if the machine were not properly designed; if properly designed there would be considerable.

339 x-Q. What do you mean by "considerable"—half, one-third, quarter, or what?

A. I can add nothing further to the answer already given; the question is simply a bypothetical one, and the result would depend very largely upon the knowledge of the person who designed and con-
structed said machine. 195

340 x-Q. When did you first commence to construct your No. 4 electric light machines, an armature of one of which has been put in evidence?

A. In the year 1878.

341 x-Q. How early in the year?

A. I should say about the middle part of the year, without having examined anything to enable me to answer your question more definitely than that.

342 x-Q. How early did you have any of said No. 4 machines completed, ready for use?

A. I cannot say, but it was very shortly after the machine was started.

343 x-Q. Before the end of 1878?

196 A. I think so; I do not wish, however, to be too positive in relation to this, as I have had no opportunity of examining any papers to refresh my memory in regard to it.

344 x-Q. You stated in your direct examination that in April, 1879, you ordered certain copper bars and sheets of Messrs. Staniar & Laffey; you also stated that that order was not filled. Why was it not filled?

A. Partly, I think, on account of their not having rollers large enough to roll the bars; and, further, because the Board of Directors did not approve of building more machines than we then had.

197 345 x-Q. Did you order said copper sheets and bars without permission of the Board of Directors?

A. Yes, sir; but not without the knowledge of some of the Board of Directors; notably Mr. Havell.

346 x-Q. When you found that Messrs Staniar & Laffey could not fill said order did you ever order any such sheets or bars elsewhere?

A. No; although I think Mr. Havell suggested that I could get them from Messrs. Hendricks Bros., if not in the form of bars, at least in the form of slabs, from which the bars could be cut.

347 x-Q. How soon after giving the order did you learn that the order could not be filled?

198 A. Not until quite some time after, as the principal member of the firm of Staniar & Laffey was then in Europe, I think, and this caused some delay.

348 x-Q. How long a delay?

A. Probably as much as a month.

349 x-Q. Did you ever bring the subject of making the machines with end-disk connections before the Board of Directors of your company?

A. Yes, and described the matter in detail to at least two, if not more of the directors.

350 x-Q. When did you bring the matter before the Board of Directors, officially?

A. Certainly as early as the month of April, 199
1879.

351 x-Q. Were minutes kept of the proceedings of the Board of Directors?

A. Yes; very general ones.

352 x Q. Did you ever make any written communication to the Board of Directors on the subject?

A. No.

353 x-Q. Who was it on the Board of Directors who declined to give their consent to your constructing any such machines?

A. Nearly all of the directors, notably Mr. H. P. Baldwin, who decidedly objected not only to the 200
construction but also to patenting almost any new thing that I brought up, on account of the straightened condition of the company and the necessary expense; in fact, to the best of my recollection, there were only two members of the board at all favorable to the construction of such machines, viz., Mr. Van Winkle and myself, both of whom were actively engaged in the business.

354 x-Q. And who were those who were opposed?

A. Mr. Baldwin, Mr. Roberts, Mr. Havell, and I think Mr. Condit, although Mr. Condit at first was very much interested in the matter of the application of these machines to the refining of copper, and 201
went personally to see Messrs. Hendricks Bros. in relation to the chances of success in refining copper by such machines; and at the time named I think there was some effort made on his part to induce Messrs. Hendricks Bros. to take up the matter.

355 x-Q. Was any resolution ever passed upon the subject of these machines by the Board of Directors?

A. No formal resolution, but practically, such a resolution was passed.

356 x-Q. What do you mean by such a resolution being practically passed but not formally passed?

A. Members of the board, after considering our

202 financial condition, signified their disapproval of the matter.

357 x-Q. Was said disapproval ever rescinded or altered in any way?

A. No, sir.

358 x-Q. In what way were the armatures of your No. 4 Electric Light Machine wound?

A. With copper wire in substantially the manner described in the patent No. 209,532, and identical with the manner which is described in my application for the patent which is the subject-matter of this interference; the portions of wire crossing the ends of the armature corresponding both in func-
203 tion and operation with the end-disks.

359 x-Q. You don't mean to say, do you, that any of your No. 4 Electric Light Machines ever were provided with end-disks, as described in your application now in interference?

A. No sir; what I mean is that the two machines are identical in construction and operation, and that it is solely a question of the mechanical adaptation of the disks and bars for the purpose specified.

360 x-Q. Which is the most expensive way of winding the armature, that by wires, as described in your patent 209,532, or that described in the
204 application now in interference?

A. It would depend entirely upon the use to which the machine was to be put. If used for a voltaic arc light of the ordinary power, then the wires would be the cheapest and best to use; on the contrary, if the machine was required for the purpose of producing currents of enormous volume and comparatively low intensity, then the copper disk and bar form would be the cheapest. These questions, however, cannot be answered definitely without stating the relative sizes and uses of the machines.

361 x-Q. In 1879 was your company having a considerable sale of your No. 4 electric light machine?

A. Yes, a moderate sale—not a very large one. 205

362 x-Q. Was your No. 4 electric light machine your largest size electric light machine?

A. Yes, the largest we then constructed.

363 x-Q. How did the No. 4 electric light machine compare with the largest sized machines for electrotyping or electro-plating which you were constructing?

A. It is impossible to answer the question, because the two machines produced currents of very different qualities and were used for very different purposes. For instance, it would have been practically impossible to obtain a current from the machine described in the patent No. 180,082 which 206
would furnish a current of such tension as was furnished by the No. 4 electric light machine; on the contrary, it was possible to construct the No. 4 electric light machine to furnish a current exactly like the current obtainable from the machine described in the patent No. 180,082.

364 x-Q. Suppose your No. 4 electric light machine had been provided with longitudinal conductors and end-disk connections, and thereby adapted for use for electrotyping or electro-plating, how would such machine compare in size with the largest sized electrotyping or electro-plating machine your company was constructing at the time?

A. A machine based upon the electric light plan 207
would have been larger than the other machine, and certainly much more costly. We never built many large machines of the style shown and described in the patent No. 180,082—not more than half a dozen, I think, as there was very little demand for such large machines either in the art of electro-plating or electrotyping.

365 x-Q. In your third answer you said that in January or February of 1881 you told the foreman of your shop not to build any more of the large electrotyping or electro-plating machines. How large were those large electrotyping or electro-plating machines to which you referred?

208 A. Smaller than the largest one of which I spoke in my last answer.

366 x Q. Do you mean smaller than the No. 4 electric light machine?

A. No; I mean smaller than the largest machine that we had ever built of the type shown and described in the Letters Patent No. 180,082, and consequently it would be smaller than the No. 4 electric light machine.

367 x-Q. What was the diameter of the ring or shell of the machine which you spoke of in your answer as the large electrotyping or electro-plating machine?

209 A. Sixteen inches.

368 x-Q. And were those made under the patent 180,082?

A. Yes.

369 x-Q. For how long a time had you been making these 16-inch machines?

A. We never made, I think, more than two lots of such machines, and not more than three or four of each lot, according to the best of my recollection. The machine was originally designed in the year 1877, and the patterns were slightly altered before the second lot of machines was built, which was quite some time after.

210 370 x Q. In what year was the first lot built and what year the second lot?

A. The first lot was built in 1877, I believe, and the second lot was built in 1878, according to my best recollection and present knowledge.

371 x-Q. Can you name any person to whom you sold any of said large electro-typing or electro-plating machines?

A. Yes.

372 x-Q. To whom?

A. Messrs. Weed, Parsons & Co., of Albany, and Charles Craske of New York.

373 x-Q. Did you furnish any such machines to Messrs. Roberts & Havell for their plating business?

A. No, sir; all the machines that were furnished 211
for electro-plating were much smaller than the machines I have referred to. The electro-plating machines were not more than half the size of the machines already referred to, although the diameter of the cylinder in some of the early forms of plating machines was nearly equal to the largest machine of which I have spoken; these machines did not weigh, however, more than one-fourth of the largest machine.

374 x-Q. What was the size of the large electroplating machines you told your foreman, in January or February, 1881, not to build any more of? I understand your previous answers have reference 212
to electro-typing machines.

A. These machines had cylinders 14 inches in diameter and 16 inches long; they were used both for the purpose of electro-plating and electro-typing purposes, and not, as you have supposed, for electro-plating only.

375 x Q. Did Messrs. Roberts & Havell have any of those electro-plating machines?

A. No, sir; they used a still smaller one.

376 x-Q. How long had your company been manufacturing electro-plating machines?

A. About the same time as they had been manufacturing the 16-inch machines, but they sold a few more of those machines than of the larger 213
machines.

377 x-Q. Did you have any foreman under you in the years 1875, 6 or 7, if so, who was it?

A. Yes, Mr. John Gormley was foreman of the plating department of my shop in Centre street, New York, in 1875. In 1876 Mr. Havell and myself both managed the men; Mr. Havell frequently attending to the shop during my absence, in putting up and instructing persons in the use of machines built. In 1877 we had no regularly authorized foreman of the entire shop except myself; although a man by the name of Broadbent superintended, to a

214 certain extent, the mechanical construction of the plating and other machines that we were building.

378 x-Q. Who was your foreman in 1878 and '79?

A. Mr. Broadbent continued to fill the same position as I have already indicated. In 1879 Mr. Joseph Bradley was hired to take the mechanical work entirely off my shoulders.

Adjourned to Wednesday, Feb. 15th, at 11 A. M.

Feb. 15th. 1882.

215 Met pursuant to adjournment.

Present—Counsel for the respective parties as before.

Cross-examination of EDWARD WESTON continued by Mr. Betts.

379 x-Q. Between the time of the organization of the Weston Dynamo Electric Machine Company, and the beginning of the year 1881, how many patents did you obtain relating to Dynamo-electric machines?

A. About four, I think.

380 x-Q. And did you file any applications which were not allowed, if so, how many?

216 A. None for dynamo-electric machines, that were not allowed; but I did not proceed with some cases which were originally put in the hands of Messrs. Alexander & Mason just about the time of the organization of the company; since the change in the management and direction of the company I have, however, applied for some of these cases.

381 x-Q. What is the change in the management and direction of the company to which you refer?

A. Some New York parties took hold of the company, purchased most of the stock of the company, and now have control of it.

382 x-Q. Were those parties the managers of the United States Electric Lighting Company?

A. Some of them, but very few, according to my best knowledge and belief, were interested also in the United States Electric Lighting Company. 217

383 x-Q. Is not your company now practically united in interest with the United States Electric Lighting Company?

A. Yes; they have a mutual arrangement by which they work together.

384 x-Q. When you speak of certain applications for patents having been placed in the hands of Messrs. Alexander & Mason, do you mean that the applications were prepared, but not filed?

A. They were partly prepared and not filed.

385 x-Q. What do you mean by "partly prepared?" 218

A. I mean that the cases were never so completed as to be in a condition to file. I mean, in other words, that the papers were never put in proper shape for final application.

386 x-Q. Do you mean that papers for applications for patents were partly prepared, but not completed?

A. I mean just what I stated in the last answer, which I think is a perfect answer to your present question.

387 x-Q. Were papers for the application now in interference ever prepared at all by Messrs. Alexander & Mason? 219

A. Not for the case precisely as it stands to-day; although there was quite a similarity between one of the cases now in interference.

388 x-Q. Have you any objection to state what the case was which you say bore quite a similarity to the case now in interference?

A. Yes; I have some objection; I am not willing to divulge to others, or the counsel of others, who are engaged in the same line of business, inventions for which I have not, so far, obtained patents.

389 x-Q. Did the papers which you say were partly prepared by Messrs. Alexander & Mason, and which you say bore quite a similarity to the case now in in-

220 terence, show or describe the subject-matter of your present claims?

A. Strictly speaking, no.

390 x-Q. How did it happen that you made your application which is involved in the present interference at the time you did?

A. It was like other applications which had been neglected, prior to the reorganization of the company and the company being supplied with the necessary funds to conduct its business in a proper manner.

391 x-Q. Was not your present application filed until after the reorganization of your company, of
221 which you have spoken?

A. No, sir; it was not.

392 x-Q. Can you give any reason for the taking up of the subject-matter of your present application and the filing of the said application at the time you did file it, other than what you have given?

A. Yes; I considered myself entitled to a patent for an invention which I had made long ago and which was practically but a slight modification of a machine already described and patented by me. And, again: The present state of the art indicates a great development, and considerable call for very large machines.

222 393 x-Q. Who had called at that time for very large machines?

A. Mr. Curtis, who was then, and is still, Secretary of the United States Electric Lighting Company, spoke to me about building a 500 light incandescent machine; and I also knew that we could sell large electrotyping machines built upon this plan; as I have already testified, on my direct-examination.

394 x-Q. Had anybody else besides Mr. Curtis spoken to you about any large machine?

A. Yes; a Mr. Holder, who was then in Baltimore, refining copper, wanted me very much to build him such a machine; which I promised to do at the earliest opportunity.

395 x-Q. Any one else? 223

A. No one else that I can think of, at that period.

396 x-Q. When did Mr. Holder express this wish to you?

A. Some time in the latter part of 1880 or the early part of 1881.

397 x-Q. Did Mr. Curtis ever order any machine of you, such as you have referred to?

A. No; although it was understood that I was to build one as soon as I could conveniently and consistently, without interfering with my other work.

398 x-Q. Were you aware when you filed your application now in interference that Mr. Edison, 224
was employing bars and end disks on the armatures of machines of this construction?

A. Yes, sir.

399 x-Q. How long had you known of that?

A. But a very short time; not more than a few days, I think, before I took steps to file my petition.

400 x-Q. Who informed you of what Mr. Edison was doing?

A. The information came through Prof. Morton, I believe, who had made a test of Edison's machines.

401 x-Q. Is Prof. Morton one of the experts of the United States Electric Lighting Company?

A. I think so, although I think he is also opposed 225
to it in some cases.

402 x-Q. Did Prof. Morton give you this information personally; if not, who did so give it to you?

A. I am not quite sure; I think I met Prof. Morton once and the information was communicated at that time; but I am not certain of this.

403 x-Q. Were you aware when you filed your present application that Mr. Edison had filed an application for a patent for the subject-matter of the present interference?

A. Yes.

404 x-Q. Who told you that?

A. I believe it was Mr. Curtis; I then told him about the condition of affairs and of my having in-

226 vented the thing a long time prior to the time that
he told me about it.

405 x-Q. When was it that you received this information from Mr. Curtis?

A. I cannot now fix the date, as I have no memorandum which would enable me to do so, but it was a very short time before the application was finally filed.

406 x-Q. How came Mr. Curtis to know about Mr. Edison's application for a patent?

A. You will have to inquire of Mr. Curtis in relation to that. I am not sure that Mr. Curtis really
knew, but probably supposed that Mr. Edison had
227 filed an application, as is usual with him, whether
it is good, bad or indifferent.

407 x-Q. Who prepared your application which is now in interference?

A. Mr. Page and Major Bailey.

408 x-Q. Please give Mr. Page's full name?

A. Parker W. Page; I don't know the middle name; I give you the initials only.

409 x-Q. Had Mr. Parker W. Page then recently been an officer of the United States Patent Office?

A. I don't know.

410 x-Q. What is your information on that point?

A. I know that he was at one time in the office; when he left I cannot say.

228 411 x-Q. Is it you information that he was an ex-
aminer of the class which included dynamo-electric
machines?

A. Yes; I met Mr. Page in the Patent Office in 1879.

412 x-Q. Is it not your information that at the time you filed your present application he had recently resigned as Examiner of that class?

A. I have no information which would enable me to form any opinion as to when he did resign, and I have no information from which I can draw any conclusion whatever in relation to the matter; the records of the Patent Office will give you all the information you desire in this direction.

413 x-Q. Is Mr. Parker W. Page employed by the 229
United States Electric Lighting Company?

A. According to the best of my knowledge, only in the capacity in which any other attorney or counsel would be.

414 x-Q. He is so employed, is he not?

A. He is so employed as attorney or counsel, I believe, yes.

415 x-Q. Did Mr. Page inform you that Mr. Edison had an application for the subject-matter of this interference pending?

Objected to as irrelevant and immaterial,
and as inquiring into communications be-
tween counsel and client. 230

A. Not until after steps had been taken to file my application or to draw my application, according to my best recollection at the present moment.

416 x-Q. Did he do so before you filed your application?

Same objection.

A. I think it very likely that he did.

417 x-Q. Have the Weston Electric Light Company ever sold any dynamo-electric machines for use in connection with incandescent lamps?

A. I have no doubt they have.

418 x-Q. Do you *know* that they have?

A. No, sir; the proper officers of the company 231
could inform you in relation to this matter, I suppose.

419 x-Q. You spoke, in the early part of your cross-examination, of the capital stock of the Weston Dynamo-Electric Machine Company having been $200,000. Was any portion of that ever paid in, with the exception of the $12,500 of which you spoke?

Objected to as irrelevant and immaterial.

A. Yes.

420 x-Q. How much of it?

A. A certain proportion was paid in, with which

232 the patents were purchased from Messrs. Stevens, Roberts Havell and myself, who, of course, originally owned all the property and title to said patents. Subsequently small amounts were paid in, but never a sufficient amount to properly conduct the business, or to establish the company on even a moderately fair financial basis.

421 x Q. How much was paid in in all?

Same objection.

A. The total amount that was paid in up to January, 1881, including the amount that had been paid for the patents and other property held by the
233 original owners, was something like about $125,000; which was an amount altogether incommensurate to the business, and consequently the company was kept in very straightened circumstances.

422 x-Q. In your direct examination you spoke of having told the foreman of your shop not to build any more of the large electrotyping or electroplating machines, as you proposed to use ordinary electric light machine armatures wound with copper bars and disks instead. When was that direction to your foreman given, with reference to the time of the reorganization of your company by the purchasing of the controlling interest in the stock
234 by New York parties?

A. I think it was very near the time, but I am not quite sure. I can fix the date exactly, or very nearly, by referring to the books, which would enable me to state precisely when the present foreman, Mr. Parsons, was first employed by the company.

423 x-Q. Can you say whether it was before or after the reorganization?

A. I think it was after—or at least after the negotiations had taken such shape as to render things perfectly sure of being carried through.

424 x-Q. Did your company become practically united in the interest with the United States Elec-

tric Lighting Company, at the time of the reorganization you have spoken of? 235

A. No, sir.

425 x-Q. Soon afterwards?

A. No, sir.

426 x-Q. Can you give the date of the reorganization of your company of which you have spoken?

A. Very closely.

427 x-Q. When was it?

A. About February or March, 1881.

428 x-Q. When was this direction to your foreman given, with reference to the time of filing your application for the patent now in interference? 236

A. Before it.

429 x-Q. How long before?

A. Quite some time. Before I had any intimation that Mr. Edison had built a similar machine.

430 x-Q. How long after the employment of your present foreman, Mr. Parsons, did you give this direction?

A. That I cannot answer without referring to the books.

431 x-Q. Can you fix the time of giving this direction by referring to your books, and if so, how?

A. Because I know it was not very long after Mr. Parsons first came with us.

432 x-Q. Have you any means of saying how long? 237

A. Not exactly; except that I am quite sure that I should not have given any such order until I was certain that our company was likely to be in a far better financial condition than it was before any connection with the New York parties.

433 x.Q. Who were the New York parties of whom you have spoken?

A. Charles R. Flint, Esq., was one of the moving parties, and Marcellus Hartley, Esq.

434 x-Q. What is the connection of those gentlemen with the United States Electric Lighting Company?

238 A. I really cannot tell their exact official position, but think Mr. Flint is Vice President of the Company.

435 x-Q. And the other gentleman, what is his position?

A. I do not know, except that I know that he takes a very active interest in the business.

436 x-Q. Will you produce here the book by which you can tell when Mr. Parsons became your superintendent?

A. Yes.

437 x-Q. Please do so?

A. I will, at the next adjournment—or I will
239 send a messenger at once for the book.

438 x-Q. Did you ever file an application for a patent for improvement in dynamo electro machines which related to the use of water for the purpose of keeping such machines cool?

A. I filed an application in which this was one of the features claimed.

439 x-Q. Can you state from memory when you filed said application, or about when?

A. Approximately, I think I can.

440 x-Q. When was it?

A. In the latter part of 1879, I believe.

441 x-Q. Has any patent been granted on that application?

240 A. Yes. The patent, however, covers a number of other devices besides the one which you specified.

442 x-Q. Did you have an interference at the Patent Office between said application and an application of William Hochhausen for a similar invention?

A. Yes, there was an interference on part of the case, viz.: that relating to the use of water in a specific manner, but not on the other branches of the case.

443 x-Q. Did the other branches of the case relate to the use of water for keeping the machine cool when in operation?

A. No.

444 x-Q. Were you examined as a witness in that

interference relating to the use of water for keeping a dynamo-electric machine cool when in operation? 241

A. Yes.

445 x-Q. Did you testify in that interference case that you conceived of that invention on or about the 17th day of January, 1877?

A. I think I testified to something of that kind. You have, as I understand, the record before you, and can judge better in relation to this than I can.

446 x-Q. Is that true, that you did conceive said invention in January, 1877?

A. If you find it in the record, undoubtedly it was true.

447 x-Q. Did you on said interference, in answer 242
to question 7—"After so conceiving the invention in controversy, what next did you do concerning it?" say as follows: "I talked with several parties about it, and discussed it in detail with a man who had charge of my shop at that time, and proposed to use it on large machines as soon as they were required. Some time in July or August, 1877, we began to think about constructing much larger machines than we had heretofore done, in which this mode of keeping the armature and magnets cool was to be employed, but up to about that time we had been as busy as we could be, our shop being run almost night and day in the manufacture of 243
small machines to be used principally for electro-plating, consequently the delay in the application of it resulted in our inability to do anything more than we were doing on small machines. In fact, we were so busy that we had to get a very large amount of work done outside, and could not keep up to our orders then"?

A. The record speaks for itself. The quotation appears to be correct. The man referred to was only in charge of the shop in a very limited sense. For the information of counsel, I will state, substantially, the condition of the art in those days. The whole shop was really under my control and

244 direction, necessarily, because but few men had had any practical experience in this country in the construction of any such machines as are referred to.

448 x Q. Who was the man who had charge of your shop at that time, as referred to in your answer which has been quoted above?

A. In the limited sense in which I have here expressed it, Mr. Levi Broadbent.

449 x-Q. Were you, on your examination in said interference case, also asked the following question: [Q. 8]. "State whether you employed any means for cooling smaller machines which you manufactured at the time referred to in your last
245 answer," and did you not answer as follows: "In all machines that were made by me from some time in the early part of 1875 until January, 1877, I employed no means of cooling machines whatever, but after January, 1877, I did employ water for keeping the 12-inch machine (which is quite a small one) cool. In this machine I made a slight alteration, which, without interfering with the structure of the machine, except so far as the magnets are concerned, enabled me to keep that sized machine sufficiently cool for all purposes for which it was made. This change was made owing to the fact that we put in one of these machines at the Meriden
246 Brittania Company in the early part of January, 1877. The shop of the Meriden Britannia Company is probably the largest silver-plating shop in the world, and they gave the machine we first sent them such an amount of work to do that it caused the machine to heat sufficiently to injure the insulating material; in machines we were then building, of which we had quite a large number in process of construction, the armature was inserted on bearings extending from arms running parallel with and on both sides of the axis and fastened on each side of the shell by bolts; at a distance of about three inches from the end of the cylinder or shell the arms were bent at right angles, and in this way formed a cross-bar, in which the bearings were placed; a pro-

jection was cast on the side of the shell which was 247
milled out, so as to enable the arms to be fitted tightly and held rigidly in their places." (You then introduced a sketch illustrating the machine, and continued:) "In order to introduce water into the machine for keeping it cool without seriously interfering with its construction, I determined to cast the magnets hollow and to connect the spaces in the cores of the magnets together in such a manner that the water would flow through the magnets successively; this I did, tested the machine—or rather gave instructions to Mr. Stebbins and Mr. Allen (men in my employ)—to test the machine by running with very slight resistance in the circuit, for 248
four hours, and to report to me the result; if it would not answer the purpose, I told them that I would have to change the construction of the machine we had then, by putting heads with bearings attached on the cylinder of the machine, thus tightly closing up the ends, and running water through machine in direct contact with the armature. As the water running through the magnets answered for this size of machine, we did not change the construction in the manner proposed, but resolved to do it on larger machines; we afterwards, however, put heads with bearings attached on all the machines we made, but did not change the cooling device on the 12 inch machine. We do 249
not use any water on the two smaller sizes of machines we use, and never have"?

A. Yes; the statement, however, must be taken in the restricted sense in which it is given and considered as applying to those machines which were really the subject-matter in dispute. The subject-matter in dispute was a specific mode of cooling a machine used for electro-plating purposes by the passage of a stream of water, not through the coils, but through the iron shell which surrounded the machine and to which the magnets were bolted. To make the answer cover all machines which I built would be to stretch the issue beyond its proper lim

250 its, and therefore it must be read in connection with the whole of the matter which was the subject in dispute.

450 x-Q. You stated that you thought that your application for a patent relating to the use of water for keeping a dynamo electric machine cool was filed in the latter part of 1879. Will you please look at the record in that interference, which I now hand you (handing document to witness), and state whether you have not made an error of about two years in the date, and whether the application was not filed on December 13th, 1877, and whether your evidence in the case was not given as early as April, 1879?

251 A. Yes; I presume the delay in taking the testimony is the cause of the mistake; I have not looked at the record nor any of the facts relating to it, otherwise I could have answered you definitely and precisely. It is just to myself, I suppose, to make this statement, as I had not anticipated any cross-examination upon any such matters, otherwise I would have refreshed my memory before testifying. I knew it was in the latter part of some year, and believed it was in the month of December. I was somewhat misled by the delays in the case and the taking of the testimony in the year 1879.

451 x-Q. Have you now here the book which will

252 enable you to state the exact date when Mr. Parsons became superintendent of your factory. If you have the book, please give such exact date?

A. Yes, sir [referring to book]. He was first employed on October the 24th, 1880.

It is agreed between counsel that either party may, at the hearing of this case, refer to the whole of the evidence of the witness Weston in the interference case between Weston and Hochhausen, so far as it may bear upon the matters referred to in the quotations from that record made in the course of this cross-examination.

Re-direct:

452 Q. In your cross-examination you have stated that it is cheaper to construct a machine with end-disk connections and longitudinal conductors than other forms of dynamo-electric machines ordinarily made, in the case of a given machine, to produce a given result; also that there is a saving or economy by reason of the use of end-disk connections in place of over-lapping wires at the ends of the armature, in the case of a given machine, to produce a given result. Please state a case, in order to illustrate your meaning more clearly? 253

A. Take the case of the machine described in my patent No. 209,532 as an example. It would be 254 easier and cheaper to construct such a machine for the purpsse of electro-plating by using bars and disks than by using wire I did not mean to be understood, in the answers to which you have referred, as speaking of any machines except such machines as are built upon the general plan described in the patent above referred to.

453 Q. Referring to your answers to cross-questions 208 and 209, what, in a general way, was the Siemens machine which you knew of, and when did you first know of it?

A. A machine which has a cylindrical armature somewhat similar to the armature described in my patent No. 209,532. I did not know of the ma- 255 chine having been constructed until after the opening of the Paris Exhibition, in 1881, when I saw a cut of it in some journal.

454 Q. Referring to your statement that you took up the subject again in the early part of the year 1879 and constructed several machines, what led you to do this, any special circumstance?

A. Yes.

455 Q. What was it?

A. My experience while in Boston at Messrs. Whitcomb & Co.'s shop in Milk street; also my

256 connection with Mr. Craske, the electro-plater, of New York.

456 Q. What was your experience with Whitcomb & Co., of Boston, and when did you have it?

A. Their machine had become injured by reason of some defect in the water cooling apparatus on the field magnets; I cannot fix the date exactly, but it was a short time prior to the month of April, 1879.

457 Q. In answer to cross-question 287, you say that you had some difficulty, due to the over heating of your machines. To what machines did you have reference in that answer?

257 A. The machines which we regularly manufactured, such as are described in my patent No. 108,-082 and used for the purpose of the electro-deposition of metals.

458 Q. Did you have the same difficulty with your electric light machines, such as are constructed on the plan illustrated in your patent 209,532?

A. Yes; but the light machines are generally worked on nearly a fixed external resistance over which the operator has little or no control; whereas, with machines for electro-plating or electrotyping purposes the operator may put more or less work into the vats and thus cause the machine to
258 heat more or less, according to the amount of work put in. I may state here that all machines will become over-heated if not worked upon a fixed resistance, the limits of which should never be exceeded, and the use of water in such machines really enables a person to get more work out of a given sized machine than he could otherwise, with safety.

459 Q. Does not the method of winding the armature described in your patent 209,532, tend to prevent the machine from over-heating?

A. In a certain sense, yes. The method of winding the armature therein described does not allow of the change of position of the core of the armature, as a whole, in the field of force, and the conductors cut the lines of force of the magnet at right

angles directly, and without the intervention of an 259
iron core such as is described in my patent No. 180,-082. Both these contribute to reduce the heating effects which arise in machines of the other type to which I have already referred.

460 Q. Would not this advantage attach to the method of winding, whether wire, as described in your said patent 209,532, or longitudinal conductors connected by end-disks, as described in your application in interference, were employed in said method?

A. Certainly.

461 Q. You have stated that there would be an economy or saving of power in running a machine constructed according to your application, now in 260
interference, over one constructed according to your patent No. 180,082. Would there be economy or saving of power in running a machine constructed according to your patent 209,532 over one constructed according to your patent 180,082?

A. Yes, sir.

462 Q. Can you say in which case there would be relatively the greater saving of power, whether in running a machine constructed according to your application in interference, or a machine constructed according to your patent 209,532?

A. For the ordinary uses to which these machines are put, there would be but little, if any, 261
difference between them.

463 Q. Would the fact that the armature in one case was wound with wire, and in the other case with conductors connected by end disks, have a material bearing on the question?

A. Only in the case of very large machines.

464 Q. In answer to cross-question 314, referring to Exhibit Weston No. 3, you say that, "instructions were given at the time to have that cylinder split longitudinally." Please explain more fully what you mean by "split longitudinally."

A. The outer cylinder of copper, or more properly

262 speaking, cylindrical tube of copper only was to be split, and not the disk at the end.

465 Q. Do you remember into how many pieces or strips you proposed to have it split longitudinally?

A. No, I do not remember how many, but several.

466 Q. What object did you have in view in so dividing it.

A. To prevant the flow of the current from points of higher to points of lower potential on the cylinder, except in the direction in which they were required, viz., in the direction of the slits.

263 467 Q. In your answer to cross-questions 289 and 290 you stated that you first adopted the device of the passage of a stream of water through spaces in the core of the electro-magnets early in 1877. In view of the matter which, in cross-examination has been read from the record in the interference case of Hochhausen *vs.* Weston, have you any reason to doubt the correctness of your testimony in answer to the cross-questions referred to? Please state your reason in connection with the answer you may give on this point?

A. I have no reason to doubt the same; on the contrary, I find that the time named from memory
264 corresponded exactly with the time as fixed in the record; and the quotation, read by Mr. Betts, from question 8 of that record fixes the date as being January, 1877.

Re-cross:

468 x-Q. In the quotation from the record in the case of Hochhausen *vs.* Weston, it appears that you said that "some time in July or August, 1877, we began to think about constructing much larger machines than we had heretofore done, in which this mode of keeping the armature and magnets cool was to be employed." Were those larger machines the first machines in which you adopted this

method of keeping the armature and magnets cool? 265

A. That there may be no misunderstanding on this point, I will state the facts on this record. I had previously used a stream of water passing through the cores of the electro-magnets of my plating machine, and the improvement which was the subject matter of the interference to which you have referred consisted simply of putting the water *outside* of the cores and *in* the iron shell, so that it not only came in contact with the cores but also in contact with the armature; there was, however, a slight change made in the mode of insulating parts of the machines described. viz.: they were coated with some water-
proof substance in addition to the ordinary insulat- 266
ing material which was generally used. I do not wish the counsel to understand that the 16-inch machines we were then building were very large machines. The earlier form of machines weighed about 800 pounds, which, at that time, was considered a fair weight for a machine; to-day, however, we should consider such a machine comparatively small, as we now build machines that, instead of weighing hundreds of pounds, weigh tons. For example, nine-tenths of the plating establishments in this country who are using our plating machines use the so-called 12-inch machine, a machine which
only weighs a little over 300 pounds; and a very 267
large number of plating establishments throughout this country use our 8-inch machines, which weighs but 178 pounds. This latter machine, in the early stages of the art, weighed 67 pounds, and the former 225. The additional weight which was added to the machine was mainly to give the machine greater mechanical strength and stability, so as to stand the strains to which such machines are subjected in every day use.

469 x-Q. When did you first adopt, in connection with any of your machines, the device for the passage of a stream of water through spaces in the core of the electro-magnets?

268 A. I cannot now precisely fix the date, but am quite sure that it was on or before the month of March, 1877.

470 x-Q. Why do you say on or before the month of March, 1877?

A. Because I recollect making a visit to the Meriden Britannia Company to put up one of these machines about that time. It was a second visit, after the first visit, which you will find described in the record which you have in your hand. From my best recollection at the present moment, and without having refreshed my memory by referring to anything connected with it, except such as you
269 have quoted here, I should say that that machine was started in the month of February.

471 x-Q. Have you any reason for giving that date rather than any other?

A. Yes, I have an indistinct recollection of an entry which was made in a record book of machines sent out, and further, the date is somewhat clearly fixed in my mind from the fact that at this second visit I put up at least five or six machines in the City of Meriden to displace machines of another maker which had been tried and found wanting.

472 x-Q. Which form of winding the armature
270 would be most efficient to prevent over-heating, the form of wire that is described in your patent No. 209,532, or the longitudinal conductors and end-disk connection?

A. With two precisely similar (in every other respect) and small machines, I think you would scarcely be able to detect the difference. Your question does not admit of an answer in a general sense, because in smaller machines it would be next to impossible to use the number of disks necessary for the production of a machine to furnish a voltaic arc light. Let me give an example: Our 10-light machine has 640 convolutions of wire on its armature, which practically means that the wire overlaps the ends 640 times; now, of course, it would be practi-

cally useless to attempt to construct a machine of 271
this kind, with copper disks on the ends, from the fact that you would require 640 disks and 1,280 joints on each end of the armature, a condition of affairs which no intelligent person at all acquainted with the subject would think of for a moment.

473 x-Q. What do you mean by "ordinary use" of the machines described in your patent No. 209,-532?

A. The production of a voltaic arc light.

474 x-Q. You spoke in your answer to the 466th re-direct question of the purpose you had in view in directing the copper cylinder, Exhibit Weston No. 3, to be split. Would there be a tendency to the 272
result described in your said answer if the cylinder was used without being split?

A. There would be such a tendency as is there referred to.

April 17th, 1882.

Edward Weston, being re-called for further cross-examination by counsel for Edison, testifies as follows:

475 x-Q. What was the size of wire used for wind- 273
ing the field magnets in the machine of 1875 referred to in Exhibit No. 1?

A. About No. 12 as near as I can now remember.

476 x Q. How many times around the magnets was such wire wound?

A. That I don't know; there was quite a large number of layers.

477 x-Q. State as near as you can.

A. I should say there were six or eight layers.

478 x-Q. Was the wire of each layer wound in coils close together?

A. Yes, sir.

479 x-Q. Please state the dimensions of the machine referred to in Exhibit Weston No. 4?

274 A. I cannot give you the precise dimensions; I can give you somewhere near it. The magnets were about 10 inches long, 4½ inches wide, the armature about 3¼ in diameter and 10 inches long; the iron core of the armature was about six inches long; the length of the armature shaft was about 18 inches.

480 x-Q. Give the size of the wires which you used in the field magnets?

A. About No. 12 or 14.

481 x-Q. And how many turns?

A. That I cannot say; three were several layers.

482 x-Q. What was the size of the wire on the
275 armature?

A. I think the wire on the armature was about No. 10; I am not quite certain on this, though.

483 x-Q. How many longitudinal wires were there on the armature?

A. I believe there were 32.

484 x-Q. And how many disks were there?

A. Eight on each end, I believe.

485 x-Q. Who built this machine?

A. I think Mr. Emil Scheuten did most of the mechanical work; I believe he did it under contract with Mr. Bradley.

486 x-Q. What Mr. Bradley is that?

A. Mr. Bradley, who is now in the employ of Mr.
276 Edison.

487 x-Q. Was this machine built from any drawings?

A. Not that I am aware of; sketches I think, however, were made.

488 x-Q. Where is Mr. Emil Scheuten?

A. He is now working for Messrs. J. Bunnell & Co., I think, of Liberty street, New York.

489 x-Q. What was the thickness of the copper disks on this machine?

A. Something less than the 16th of an inch, according to my best recollection—not under a thirty-second, I think, and not over a sixteenth.

490 x-Q. Of what material were the field mag- 277
nets?

A. Cast iron.

491 x-Q. How did this machine compare in efficiency with the electro-plating dynamo-electric machines which your company were then building?

A. I made no absolute measurements by dynamometer, and therefore cannot say; I have no doubt, however, that it was not as efficient, in proportion to its size, as our other machines.

492 x-Q. Was more than one test ever made of this machine?

A. Yes.

493 x-Q. How many?

A. I cannot say how many; but several. 278

494 x-Q. Where were all these tests made?

A. Mainly in the shop of Messrs. Roberts & Havell.

495 x-Q. Plating shop?

A. Yes; the plating shop of Messrs. Roberts & Havell. Some tests were also made in the basement of the building occupied by the Weston Dynamo-Electric Machine Company. I also think the machine was run off the fly-wheel of the lathe in the laboratory adjoining the factory.

496 x-Q. How many tests of this machine were made in the plating shop of Messrs. Roberts &
Havell? 279

A. I do not know; the machine was probably run, off and on, for several days.

497 x-Q. Do you mean that it remained in the plating shop of Messrs. Roberts & Havell for several days and was subjected to tests from time to time, if not, what do you mean?

A. Yes.

498 x-Q. Did you superintend any of these tests?

A. Yes.

499 x-Q. How many?

A. Several; I cannot say how many.

500 x-Q. About how many days did it remain in Roberts & Havell's plating shop?

280 A. Two or three days; probably more.

501 x-Q. Why do you say "probably more"?

A. Because we had to put up a special pully to run it, and I think very likely some delay was caused by this.

502 x-Q. According to your best recollection, how many days was it there?

A. What I have already stated is according to my best recollection.

503 x-Q. Who else besides yourself had anything to do with those tests?

A. I think Mr. Stevens assisted in setting up the machine, and the plater who was then in the em-
281 ploy of Messrs. Roberts & Havell, but whose name I cannot now remember.

504 x-Q. What did *you* have to do with the tests?

A. I connected the machine to the vat, or the vats, and put in some of the work that was plated by the machine.

505 x-Q. How much *was* plated?

A. Quite a large number of batches; I don't recollect how many, for I kept no record of any such thing

506 x-Q. What do you mean by "a large number of batches"?

A. I mean that the tank was filled with work
282 and emptied several times.

507 x Q. About how many times do you refer to as being a large number?

A. It took about an average of half an hour for each batch to plate; the tank, or tanks, may have been filled 25 or 30 times; I couldn't say exactly; I did not remain with the machine the whole time, but left it attached to the plating solution. They plated with it in the regular course of their business.

508 x-Q. Did the machine work as fast as the other machines which were in use there?

A. No; not quite.

EDWARD WESTON.

Jany. 23d, 1882. 283

PROF. BENJAMIN SILLIMAN, a witness called on behalf of Edward Weston, being duly sworn, deposes and says:

1 Q. Please state your name, age, residence and occupation?

A. My name is Benjamin Silliman, of lawful age, residence New Haven, Connecticut. I am Professor of Chemistry at Yale College.

2 Q. Do you know Edward Weston, one of the parties to this interference. and if yea, how long have you known him?

A. I have known Mr. Weston since the summer of 1879.

3 Q. Had you occasion before that time to com- 284
municate with Mr. Weston, if yea, about how long before, and what was the occasion for that communication?

A. The first occasion that I had for communication with Mr. Weston grew out of certain experiments in which I was interested, which were being conducted at the works of the Chemical Copper Company, in Phenixville, Pennsylvania, under the administration of Mr. James Douglass, Jr., Superintendent of those works. The object of those experiments was the separation of copper from silver and other metals by electrical deposition. For that
purpose we were using the dynamo electric ma- 285
chine of Weston, such as he was then making for the use of electro-platers. This was in the early summer of 1879, before my personal acquaintance with Mr. Weston. My first interview with Mr. Weston was at his works in Newark, New Jersey, some time in the month of July, as nearly as I now recall.

4 Q. Please state as nearly as you can remember, what passed between Mr. Weston and yourself at the interview referred to?

A. We had a general discussion as to the best method of constructing a dynamo machine for the purpose in view, viz.: Of the rapid precipitation of

286 copper. Mr. Western agreed with me as to the importance, for this purpose, of building a machine with greater electrolytic power than any which he had then constructed.

5 Q. During the course of that interview, did Mr. Weston describe or explain to you how he proposed to construct a dynamo-electric machine for that purpose, and if yea, please state, as far as you remember, what that explanation or description was?

A. Either in that interview or in others immediately subsequent, Mr. Weston explained to me the method of construction which he subsequently de-
287 veloped in certain drawings which I saw in his laboratory early in the autumn of 1879; he proposed the construction of an armature which should involve two important features of construction which were new to me. First, employing a series of disks of iron placed parallel to each other and close together, for the purpose of permitting the flow of a current of air entering through an annular space surrounding the arbor or axis and escaping between the coils thus dissected; by this means the use of water circulating about the armature—a device up to that time generally adopted—was avoided. Second, Mr. Weston explained to me, and illustrated his explanation by an armature in the process of
288 construction, a method of avoiding the practical inconvenience resulting from the employment of voluminous copper conductors when the same are bent around the ends of an armature, producing at the ends an inert mass of copper conductors unwieldy and inconvenient. Mr. Weston's device for avoiding this well known defect of winding armatures with voluminous conductors, essential in quantity machines, such as are adapted to electro-metallurgical deposition, consisted in the employment of a series of copper disks placed in the recess at the ends of the revolving arbor insulated from each other and placed in electrical communication with the inducing conductors by means of

lugs, slots or other like mechanical contrivance, to 289
which the copper conductors were attached by screws or by solder, at convenience.

6 Q. Please examine the exhibits here shown you, and state whether you recognize any of them as being the same as or similar to the armature upon which Mr. Weston illustrated his explanation, as stated in your answer last preceding.

A. The Exhibit Weston No. 6, which is now before us, appears to me to be identical, or very similar, to the armature which Mr. Weston exhibited to me, as stated in my previous answer.

7 Q. Please state, by reference to the armature Exhibit Weston No. 6, where, as you understood
Mr. Weston's explanation, the conductors were to 290
be placed, and where the connecting disks?

A. The copper conductors, whether single bars or a cluster of wires, filled the spaces recessed in the iron disks and the polar pieces at each end of the armature, and were connected alternately with the several copper disks in the manner already indicated in my former answer. These copper disks filled the recess left by the projection of the polar pieces.

8 Q. Please examine the drawings which I now hand you, marked Exhibit Weston No. 5, and state whether you recognize them?

A. As already stated in a previous answer, I saw 291
on the boards in the drawing room of Mr. Weston's factory at Newark, several sheets of diagrams prepared for the guidance of the mechanics in the construction of a machine to be built for the use of the Chemical Copper Company, upon the plan described above by me in general terms. I recognize Exhibit Weston No. 5, Sheet No. 1, as one of those diagrams, and in general, the series Nos. 1 to 6, appear to me to be the same, so far as my memory serves.

9 Q. At the time you saw the whole or a portion of Exhibit Weston No. 5, on the boards in the early autumn of 1879, was Mr. Weston present, and if

292 yea, did he say anything further to you with regard to the construction of the armature of the machine represented in the Exhibit, and if so, what did he say ?

Objected to as containing statements of fact not warranted by the testimony of the witness.

A. Mr. Weston was present, and explained to me fully his ideas as embodied in these diagrams ; his explanations at that time were in harmony with the ideas expressed in my former answers, and we agreed on the importance of this modified con-
293 struction for the purpose in view, and he further signified his willingness to expedite as speedily as possible the construction of a machine for our use. upon this plan.

Cross-examination of this witness reserved, subject to agreement of counsel.

B. SILLIMAN.

Examination adjourned to Monday, February 13th, 1882, at 10 o'clock A. M.

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294 February 16th, 1882.

Met, pursuant to adjournment.

Present—

Counsel for the respective parties as before.

William L. Stevens, a witness called on behalf of Edward Weston, being duly sworn, testifies as follows:

Examined by Mr. Bailey.

Q. State your name, age, residence, and occupation?

A. My name is William S. Stevens; my age 26; my residence Boston, Massachusetts; occupation, putting up of electric light apparatus.

2 Q. Do you know Edward Weston, one of the parties to this interference, and if so, how long have you known him ? 295

A. I do; I have known him since 1874 or '5.

3 Q. What was your occupation during the year 1879—particularly the early part of that year ?

A. I was Mr. Weston's assistant in the factory and laboratory, at Newark, New Jersey.

4 Q. Do you remember doing any work for Mr. Weston on special forms of armatures for dynamo-electric machines during that time ?

A. I do.

5 Q. Do you remember, as one of those forms, an armature having upon the exterior a copper tube ? 296

A. I do.

6 Q. State when, where, under what circumstances, and by whose direction or instructions that armature was made ?

A. The first instructions were given me at Mr. Weston's house on Wednesday, April 9th, 1879, and on the following morning I began to work upon it; most of the work being done on a foot lathe in the laboratory on Washington street, next door to the shop.

7 Q. How do you fix the date stated in your last answer ?

A. By sketches given me, and which I, myself, dated at the time. 297

Why did he date them ?

8 Q. If you have those sketches please produce them ?

A. I have the sketches and here produce them.

The witness produces the sketches referred to, which are put in evidence and marked respectively Ex. Weston Nos. 8 and 9, W. H. H., Ex'r.

9 Q. When, and by whom, was the sketch Exhibit Weston No. 8 made ?

A. On April 9th, 1879, at Mr. Weston's house in Washington street, Newark, New Jersey, by Edward Weston.

298 10 Q. Did Mr. Weston explain the sketch to you at the time, if so, what was that explanation? In your answer, please refer to the parts represented by the sketch?

A. Exhibit No. 8, represents an iron cylinder mounted upon a shaft surrounded by a copper tube insulated from said cylinder. In the first experiment the tube was to be rotated between the poles of a magnet; the cylinder was afterwards to be cut into strips, as shown in Exhibit 9; the strips being secured to the iron core by insulated screws, as shown.

11 Q. Was this Mr. Weston's explanation to you at the time?

299 A. Part of that explanation was given me by Mr. Weston on the evening of the 9th and the remainder on the 10th.

12 Q. When and by whom was the sketch Exhibit Weston No. 9 made.

A. By Edward Weston, on April 10th, 1879, at the laboratory.

13 Q. How did you understand the connections of the tube and of the strips to be made?

A. As I understood, brushes were to press against opposite ends of the cylinder, or upon opposite diameters of the cylinder.

14 Q. I had reference to the connections at the end opposite what is usually the commutator.

300 A. There is a copper disk there, to form the connection, which I put on.

15 Q. I am speaking with reference to these sketches.

A. Yes, sir; a copper disk was placed at the opposite end, to connect them, or what is usually called the pully end of our machines.

16 Q. Will you please indicate by letter in the sketches Exhibits 8 and 9, the copper disk?

A. I have marked it in each case letter *a*.

17 Q. Did you construct the armature in accordance with the plan represented in either one of the sketches referred to?

A. I did, in accordance with Exhibit No. 8.

18 Q. When.

A. About that time; I do not recollect whether immediately before or immediately after; think it was immediately after. 301

19 Q. Examine Exhibit Weston No. 3 which is shown you, and state if you recognize it?

A. (After examining Exhibit 3), I do; it is the one made by me at the date mentioned.

20 Q. State whether Mr. Weston ever mentioned or described to you about this time any change which he proposed to make in the conductor used for winding the armature of a dynamo-electric machine similar to that known as his electric light machine?

A. He did, within a period of time extending over about two weeks previous to April 9th, 1879. 302

21 Q. What was the change which he described to you previous to April 9th, 1879; state as nearly as you can all that he said to you on the subject?

A. I think he first spoke of winding a light machine armature with copper bars half inch thick by inch wide, and laughed over the matter, and asked me how we were going to wind it; I told him I could see no way; but I recollect that at that time the question arose as to whether we could not cast the copper bars with the disks attached and screw and solder them together; but he finally decided that the wrought copper bars were preferable. 303
He then spoke of connecting the bars by flat copper disks at the ends, having an area equal to the cross-section of the flat bars; it was to be wound, practically, in the same way as our light machine then was, with the exception that there would be a very much less number of turns in each space than the light machine had. To the best of my recollection, he also spoke of putting only one bar in each strip, for another class of machines, connecting them all together at the back end by a large, heavy disk; as I recollect it, the commutator was to have been inside of the bearings, because the conductors were so large that we could not run them through the

304 steel bush, as we were doing with the light machines at that time. I think he also spoke of useing the bars themselves as the commutator. We had several conversations on the subject; the bars were to be connected to the disks either by dovetailing and soldering or by screwing them fast and soldering, or in some such method calculated to make a good electrical connection.

22 Q. As I understand your answer, Mr. Weston described to you at that time two kinds of machines, one in which the conductors were connected up in series, and the other in which the conductors were all connected to a single disk. How was
305 this last kind of machine to be connected up, as you understood it, in series or in multiple arc?

A. It would be practically in multiple arc.

23 Q. In regard to the machine last referred to, would it have been substantially the same as or substantially different from the armature represented in Exhibit Weston No. 9?

A. I should say it would be substantially the same, with the exception that our light machine armitures had what we called polar extensions. That is to say, the iron forming the armature projected up between the coils to a level with the same, forming a cylinder.

306 By consent of counsel, cross-examination reserved.

WM. L. STEVENS.

Feby. 16th, 1882.

HENRY PARSONS, a witness called on behalf of Edward Weston, being duly sworn, testifies as follows:

Examined by Mr. Bailey:

1 Q. What is your name, age, residence and occupation?

A. My name is Henry Parsons; my age, 48 years; 307
residence Newark, New Jersey; occupation, superintendent of the Weston factory.

2 Q. Do you know Edward Weston, one of the parties to this interference, and if so, how long have you known him?

A. I have known Mr. Weston for about 8 years.

3 Q. When did you become the superintendent of the Weston factory?

A. I think it was a year ago last September or October; I have not got the date exactly.

4 Q. From whom do you, as superintendent, receive your instructions?

A. Mr. Weston. 308

5 Q. Do you remember of having been spoken to by Mr. Weston concerning a change which he proposed to make in the construction of a large electroplating or electrotyping-dynamo electric machine; if you do, state, as nearly as you remember, when it was and what Mr. Weston said?

A. I do; I should think it was about a year ago now; Mr. Weston said that we would not build any more large plating machines; that he was going to change the construction of them, and was going to use the light machine pattern. I think he mentioned Nos. 3 and 4, and that he was going to use copper bars for winding the armature, instead of wires. I
309 think he told me that he had ordered, three years before that, copper bars for that purpose, of Stainar & Laffey. It seems to me, too, that he told me he was going to connect them by a copper disk instead of bending them around the ends of the armature; and I recollect, too, of his saying that he would let these rods go into this disk, and shoulder the rods and rivet the heads to the disk. I recollect how the subject came up and what caused it; we were making a peculiar commutator for Mitchell, Vance & Co., of New York; I asked him the reason why these spirals were made in that manner, and he said that he had—I think he called it a plating machine, made with that peculiar commutator. That

solder?

310 was the time he explained this copper rod subject to me; he told me that the disks were to be made of copper.

April 17th, 1882.

Pursuant to notice hearing resumed.

Present, counsel for the respective parties as before.

Henry Parsons, recalled:

311 *Cross-examination by* Mr. Betts:

6 x-Q. On your direct examination you spoke of a conversation with Mr. Weston about changing the pattern of plating machines, and you said you thought it was about a year ago; how do you fix that time?

A. I fix that time by coming there and finding that there were inquiries for a number of large machines, and we were short of them. That was shortly after I became connected with the company; and he told me that he was not going to build any more of those large machines; that he was going to substitute something else.

312 7 x-Q. How do those circumstances enable you to say how long it was after you became connected with the company?

A. For the exact time I couldn't tell; but I was looking up, as I had been entirely green in electrical matters, being brought right out of a machine shop where we made large steam engines and sugar-house work; I was studying up what was necessary in this establishment, getting the run of their machinery.

8 x-Q. Are you able to say anything about the month when this conversation occurred?

A. No, I couldn't say; I know it was only shortly after I had been there; I couldn't specify any

time; I never dreamt, you know, that this matter was coming to a matter of law, or ever thought of any such thing. 313

9 x-Q. Did you take any special note of the conversation at that time?

A. No notes; only recollection.

10 x Q. Did you take any special interest in the subject of the conversation which occurred?

A. Quite considerable.

11 x-Q. You narrated in your direct examination a number of changes which you said you thought Mr. Weston suggested; were all these suggestions of change made at one conversation only, or more than one conversation?

A. There was more than one conversation. 314

12 x-Q. In your direct examination, then, you grouped together the substance of several conversations?

A. The general idea—the general conversations that we had together on that subject. I would like to mention, right here, that Mr. Weston has never mentioned this subject to me since long before I ever calculated that I was to be a witness, or charged my mind with any special time; if he had I would certainly have made little notes as regards date.

13 x-Q. Over how long a time did these several conversations which you have grouped together extend?

A. I should judge two or three months; when I first became connected with the company. 315

14 x-Q. Can you say which one of the things which he described in your conversations he described in the first conversation you had with him, and which at the last?

A. I don't know as I understand you exactly.

15 x Q. You have stated in your direct examination that he suggested a number of things that he was proposing to do in regard to changing the pattern of the machine; did he suggest all of those changes at the first conversation?

A. Not all.

316 16 x-Q. Can you tell what ones he did suggest at the first conversation?

A. I think I can; he said that he calculated to use a No. 3 or 4 light machine pattern for his plating machine pattern, and that he had several years before that ordered copper bars instead of wires, and instead of wiring them, as we did our armatures, he was going to use copper bars, and had given orders to Staniar & Laffey for copper bars, but his company were at that time in such straightened circumstances and were so poor that they didn't think it advisable; that was about the substance.

317 17 x-Q. How soon after this conversation did you have any further conversation with him?

A. I think it was shortly after—not more than two weeks or a month; Mitchell, Vance & Co., of New York, sent over a commutator made very spiral, and I says to Mr. Weston, "What is this for?" He says, "For a plating machine for Mitchell, Vance & Co. that we made for them." I think he said several years before; I ain't positive as to the dates, and it was necessary, as he put this commutator on a light machine, it was necessary to have that spiral, he told me that I had better, when I rigged up my machine for doing that, I had better cut two.

318 18 x-Q. You say this second conversation occurred some two weeks or a month after the first one?

A. I think so. I know it was close to the time, but the exact time, of course, I couldn't tell.

19 x-Q. It might have been two months after, might it not?

A. No, sir, I don't think it was.

20 x-Q. Have you any reason for saying that it was not two months after?

A. Yes; I think that, as near as I can recollect, the time was from two weeks to a month from the time that I spoke to him about building more of these large machines, that this peculiar commutator came in there. I don't think it was two months; I

don't believe it was over two weeks, but that was 319
what refreshed my mind as regards his other manner of building the machines.

21 x-Q. The commutator was not built in that way, was it—as he described that he proposed to build it?

A. No, sir, not as he proposed at that time.

22 x-Q. Then what connection did it have with this suggestion of his as to this proposed mode of building the machine?

A. This new style of machine that he proposed to build was before this commutator of Mitchell & Vance came in.

23 x-Q. Do you know the date when the commu- 320
tator from Mitchell & Vance came in?

A. No, sir, I do not.

24 x-Q. At the time that the commutator of Mitchell & Vance came in, did Mr. Weston explain anything further to you on the subject of copper bars or rods?

A. Yes, sir; he told me not to build any more large machines at that time. Says I, "Mr. Weston, hadn't we better build some more large machines?" Says he, "No, don't build any more; I am going to change my plan."

25 x-Q. Then, do you mean to say that he repeated the conversation again at the time the Mit-
chell & Vance commutator came in? 321

A. I don't think he did.

26 x-Q. He didn't describe to you or explain to you anything at the time that the Mitchell & Vance commutator came in, he merely spoke of not building any more large machines?

A. Yes, sir; as near as I recollect.

27 x-Q. How soon after that occasion when the Mitchell & Vance commutator came in did you have any conversation with him in regard to the proposed new form of machine?

A. I don't think that I had, after that came in, any further conversation with him about it until about four or five months ago; I cannot specify

322 dates; I says to him, "Mr. Weston, wouldn't it be better for us to build two or three of those machines?" He says, "No, we'll build no large machines till I can build them on this new principle."

28 x-Q. That you think was four or five months ago?

A. Yes, sir.

HENRY PARSONS.

February 16th, 1882.

323 JOHN HOLMES, a witness called on behalf of Edward Weston, being duly sworn, testifies as follows:

Examined by Mr. Bailey.

1 Q. What is your name, age, residence and occupation?

A. My name is John Holmes; my age 34; residence Washington street, Newark, New Jersey; occupation machinist and tool maker; I am employed at the factory of Roberts & Havell, and have been for the last 13 years.

2 Q. Do you know Edward Weston, one of the
324 parties to this interference, if so, how long have you known him?

A. Yes, sir; I have known him seven years.

3 Q. State whether or not during the time you have been employed at Roberts & Havell's you have done any work for Mr. Weston in connection with dynamo-electric machines?

A. I have.

4 Q. When did you first begin to do such work—or any kind of work for Mr. Weston, as you now remember?

A. In the year 1875.

5 Q. What do you remember to have done for him in 1875?

A. I did work for the plating machines, and also 325
a little for the electric light machines.

6 Q. Do you remember of ever having made any rings for Mr. Weston?

A. Yes, sir.

7 Q. In what year?

A. To the best of my belief, 1875.

8 Q. State what those rings were, how they were made, their size, shape and the material of which they were composed.

A. I ought to say there, that when I had the job handed to me—which came from Mr. Weston—I didn't put the job right through; I was withdrawn to another job; but I did handle the rings; the ones 326
that I worked on were all copper, circular, about 5 or 6 inches external diameter, about $1\frac{1}{2}$ inch hole in the center, and about $\frac{1}{8}$ inch thick.

9 Q. At the time you worked on these copper rings where, to your knowledge, was Mr. Weston's place of business?

A. In New York City.

10 Q. How many of these copper rings did you make, so far as you know, at that time?

A. About one dozen.

11 Q. And where did you work on them?

A. At Messrs. Roberts & Havell's.

12 Q. At the time you were working on these
copper rings did you see any other copper rings? 327

A. Yes, sir; I saw iron rings similar to the copper ones.

13 Q. For whom were they?

A. Mr. Weston.

14 Q. How did the iron rings compare in size and shape with the copper ones on which you worked?

A. The same size externally, but larger bore in the center, and about the same thickness as the copper rings.

15 Q. Examine the rings marked Exhibit Weston No. 7, which I hand you, and state whether they resemble the iron rings you saw at that time?

328 A. They resemble much the same ring that I had to deal with.

16 Q. Did you understand the way they were formed at the time you were making the copper rings referred to, and what they were to be used in or for?

A. Yes, sir; I understood they were to be used by Mr. Weston for a light machine.

By consent of counsel, cross-examination reserved.

JOHN HOLMES.

329

J. LOUIS WALLRAFF, a witness called on behalf of Edward Weston, being duly sworn, testifies as follows:

Examined by Mr. Bailey:

1 Q. What is your name, age, residence and occupation?

A. My name is J. Louis Walraff; age 29 years; residence 105 South Orange avenue, Newark, New Jersey; occupation, electro-plater. I am employed at Roberts & Havell's, and have been employed
330 there, last, since 1876.

2 Q. Do you know Edward Weston, one of the parties to this interference, and if so, how long have you known him?

A. Yes, sir. I first saw Mr. Weston three years prior to 1876, and then didn't see him again until 1876.

3 Q. In what department in Roberts & Havell's establishment are you employed?

A. Dipping, gilding and silver-plating.

4 Q. State, if you remember, when the fire occurred at the Weston Dynamo Electric Machine Company's factory?

A. I believe it was in the early part of 1880.

5 Q. Do you remember, before that date, of a

dynamo-electric machine having been brought to 331
the nickel-plating department of Roberts & Havell for the purpose of being tested?

A. Yes, sir, I do.

6 Q. Who, as you understood, sent it there?

A. Mr. Weston.

7 Q. In what respect, if any, did that dynamo-electric machine differ from the dynamo-electric machines in use at that time for plating at Roberts & Havell's?

A. The plating machines at Roberts & Havell's were all round cylinders with the magnets attached to the cylinders, and the armature revolving in between. That is, rotary, something after the shape 332
of a plater; while this machine was built the same as Weston's light machine then in use, only it was a great deal smaller.

8 Q. Do you remember how the wires of this machine compared in size with the wire of your plating machines?

A. It was about the same thickness, if anything, thicker; I mean on the magnets; I don't know about the armature.

9 Q. What, if anything, directed your attention to this machine, and what information was given you concerning it?

A. Will. Stevens brought the machine from
Weston's laboratory, and I remarked to him that 333
it was a rather small light machine; he told me at the time that it was to be used for both lighting and plating.

10 Q. State to what use or uses the said machine was put at Roberts & Havell's for the purpose of testing it, if you know?

A. They run several tanks of nickel-plating work with it—or several batches.

11 Q. Can you state in what year this was, as nearly as you can remember?

A. I should judge it was in 1879; I don't think I can get any nearer the date than that.

12 Q. Examine Exhibit Weston No. 4 which I

334 hand you, and state whether the machine which you saw at the time stated resembled the machine there represented.

A. I don't know anything about any of the figures, but one is marked "Fig. 1" here, and it resembled that as near as I suppose you could get at it with a rough sketch.

By consent of counsel, cross-examination reserved.

April 17th, 1882.

335

J. Louis Walkaff recalled:

Cross-examination by Mr. Betts:

13 x-Q. You stated on your direct examination that you remembered a fire which occurred at the Weston Dynamo-Electric Machine Company's factory?

A. Yes, sir.

14 x-Q. Can you give the month that occurred?

A. No, sir, I cannot, positively; I *think* it was in January; I would not be positive.

15 x-Q. How much of a fire was it?

336 A. Well, the principal story—that is, the main floor, was pretty well gutted out. One end of the lower floor—that is, the basement, was more or less damaged by water, with the exception of one corner.

16 x-Q. Was Roberts & Havell's place injured at all?

A. Not the part that they used, at all.

17 x-Q. You say that you remember a certain dynamo-electric machine having been brought to the nickel-plating department of Roberts & Havell for the purpose of being tested?

A. Yes, sir.

18 x-Q. Who brought it?

A. William Stevens brought it. 337

19 x-Q. What was Mr. Stevens' position?

A. He was in the employ of the Weston Dynamo-Electric Machine company at the time, and was assisting Mr. Weston; he was mostly in the laboratory.

20 x-Q. Do you remember what his full name is?

A. His name is William—William Stevens; I couldn't tell you his middle name.

21 x-Q. William S. Stevens—is that his name?

A. I couldn't say.

22 x-Q. What makes you think it was before the fire that this machine was brought into Roberts & Havell's shop to be tested?

A. Because after the fire they moved down to 338
Plane street here, and Railroad Avenue.

23 x-Q. How do you know that they did send there before?

A. I am positive; because I saw it carried out of the laboratory next door to the factory, in Mr. Jackson's house.

24 x-Q. How soon after the fire did they move?

A. Almost immediately; they started within a week to move.

25 x-Q. How long was this machine at Roberts & Havell's plating shop to be tested?

A. I should judge it was there from about ten o'clock in the morning until between two and three 339
in the afternoon.

26 x-Q. Was it being used all the time, or only part of it?

A. It was used pretty much all that time.

27 x-Q. Where was it taken to afterwards?

A. It was taken back to the laboratory.

28 x-Q. Who superintended this test?

A. Will. Stevens.

29 x-Q. You say that this machine was like a Weston light machine?

A. Yes, sir.

30 x-Q. Are you familiar with the Weston light machine?

340 A. Yes, sir.

31 x-Q. What have you had to do with them?

A. I have seen them working there, and have always been around; I always took an interest in the plating and lighting machines, and there was a vast difference between the two machines.

32 x-Q. You say it was a great deal smaller than Weston's light machine?

A. It was considerably smaller.

33 x-Q. How large a machine was this which was tested at Roberts & Havell's?

A. Well, I couldn't exactly give you the dimensions, but I know it was considerably smaller than
341 Weston's No. 1 light machine which was made there.

34 x-Q. Can you give us any idea of the dimensions of the machine?

A. Well, I should judge it was about—that is, the field magnets were about 14 to 18 inches long and about 4 to 6 inches wide.

35 x-Q. What was the diameter of the armature?

A. Between 4 and 6 inches, I think.

36 x-Q. Do you remember which?

A. No, sir; I couldn't tell; I took no measurements; I only looked at it just while they were trying it there.

342 37 x-Q. Did you examine it particularly at all?

A. No, sir.

38 Q. Did you have anything to do with the test?

A. Nothing particular, any more than as a spectator.

39 x-Q. How much of the time were you a spectator?

A. I should judge, off and on, about an hour.

40 x-Q. What was the size of the wire on the field-magnets of this machine?

A. About the same size, if not larger; that is, heavier than the 12 inch plating machine that was in the shop.

41 x-Q. What was the guage of the wire?

A. I never guaged it; so I could not tell.

42 x Q. Can you give us any idea of the wire? 343

A. No, sir; I could not.

43 x-Q. Do you know anything about the wire that was on the armature of this machine which was tested at Roberts & Havell's?

A. No, sir; I couldn't say what wire was on that.

44 x-Q. What particular work was it that it did in this test?

A. It didn't do any work in particular, only the general run of work in the shop there.

45 x-Q. Do you remember any articles that were plated by means of it?

A. Yes, sir; I should judge they done two or 344
three batches; large and small work; there may have been five to ten gross of work plated.

46 x-Q. You say you should judge two or three batches?

A. Yes, sir.

47 x-Q. Did you take any note of how much work it did in the test?

A. No, sir; I did not.

48 x-Q. Did you examine any of the plated work that it did?

A. Yes, sir.

49 x-Q. How long before the fire was it that you saw this test?

A. I couldn't state how long before the fire; it 345
may have been three months, and it may have been a year.

50 x-Q. It may have been one month?

A. It may have been one month, but I think it was more than one; I think it was more than three.

51 x-Q. Was this machine ever tested on more than one occasion?

A. No, sir; not in the plating room, that I am aware of.

52 x-Q. If it had been, would you have seen it?

A. Yes, sir.

346 53 x-Q. Did you ever see any other machine of Weston's tested in the plating room, except the regular machines that Roberts & Havell had?

A. I have seen various different machines from that, tested there, yes, sir.

54 x-Q. When?

A. Well, before that; long before that.

55 x-Q. Years before that?

A. Well, not years; I should judge a year, or, may be six months.

56 x-Q. What kind of machines were they?

A. They were ordinary plating machines.

57 x-Q. Like those that the firm regularly used?

A. Well, they were changing them; we used a
347 wooden-base machine at that time, and we do still; and I believe, when they started to make iron-base machines, that they brought several up there to test them.

58 x-Q. And they were the ones you refer to as having been tested before?

A. Yes, sir.

59 x-Q. Those were the same construction as the regular machines?

A. Those were the same construction as the regular machines, with the exception of the base, and —well, there were other exceptions. The old style of machine had heads—brass heads, and arms run-
348 ning out from the shell, while the latter ones had the shaft run in the head of the machine.

60 x-Q. In the test of this machine, was it run regularly, or was it run for a while and then the work discontinued?

A. It was run pretty regularly. If noon hour came in between, of course they stopped then; and if I am not mistaken, they had a break down in it during the running of one of the batches that they did; that is, some of the brushes, I believe, became detached.

61 x-Q. When did that occur?

A. That was in the morning—during the morning, between ten and twelve o'clock.

62 x-Q. Was it run at all after the noon hour? 349

A. Yes, it was run a little while after the noon hour, considerably over an hour.

63 x-Q. And how long did this breakdown cause the use of the machine to be discontinued?

A. I should judge from three to five minutes; just to adjust the brush.

64 x-Q. Did you notice anything peculiar in the working of this machine during this test?

A. No, sir; she seemed to work all right and steady; if anything, she plated a little slower than the machine we had then in use.

65 x-Q. Did you examine the articles that were plated by means of this machine, carefully?

A. Yes, sir. 350

66 x-Q. Did anybody else assist Will. Stevens in the test?

A. Not that I remember; there may have been.

Re-direct:

67 Q. What is the gauge of the wire on your No. 12 plating machine?

A. I couldn't say; I have never tried it—never guaged it.

68 Q. What was done with the machine in order to make this test?

A. It was fetched from the laboratory up to our 351
room, and there was a belt put on to it and it was started to run, and it was connected up with a tank —one tank.

69 Q. And that was all that it was necessary to do in order to plate?

A. In order to test it.

70 Q. In order to plate?

A. Yes, certainly; you had to find out which way your current was running.

71 Q. That is all that was done?

A. That is all that I remember was done until it was taken away.

J. LOUIS WALLRAFF.

352 William Staniar, a witness called on behalf of Edward Weston, being duly sworn, testifies as follows:

Examined by Mr. Bailey:

1 Q. What is your name, age, residence and occupation?

A. My name is William Staniar; my age 58; residence Belleville, New Jersey; occupation manufacturer of brass and copper wire and goods; I am the senior member of the firm of Staniar & Laffey.

2 Q. How long has the firm of Staniar & Laffey been in business?

353 A. Since the 1st of July, 1866.

3 Q. Did you have any dealings with the Weston Dynamo-Electric Machine Company in the year 1879?

A. Yes, sir; that company was one of our regular customers for copper wire and brass wire.

4 Q. Do you recall having received from that company in the year 1879 an order for special forms of copper?

A. Yes, sir.

5 Q. Do your books show that order?

A. Yes, sir.

6 Q. And the date when it was received by you?

A. Yes, sir.

354 7 Q. Have you with you the book containing said order, and if so, please produce it?

A. Yes, sir, and I here produce it.

Witness produces the book referred to.

8 Q. Please point out in said book the order referred to?

A. (Referring to book.) This is April 11th, 1879, page 276, number of order 5784; it reads as follows: "April 11th, Weston Dynamo-Electric Machine Company, 10 pieces of sheet copper, 14 inches square, quarter inch thick;" also, "3 pieces, each 10 feet, 9-16 by 3 4, pure copper."

9 Q. Who, to your knowledge, received that order?

A. Myself.

10 Q. In whose handwriting is the order which you have just read? 355

A. My son's and my own.

11 Q. (Handing paper to witness.) Please examine the paper which I hand you, which purports to be a transcript of the order which you have read, and state whether it is an accurate copy of the order as it is in your book?

A. Yes, sir, it is, with a little change I made here; "3 pieces *each*" it is in our order, but it was not so here, so I have added the word *each* in between there.

The paper referred to is offered in evidence 356
and marked Ex. Weston No. 10, W. H. H., Exr.

12 Q. Who gave you the order?

A. A man they called Mr. Young; he came frequently with their orders, and it was the same old gentleman that always came.

13 Q. Did you fill the order?

A. No, sir; I am not quite sure now; it strikes me that the square plates were filled and the other not filled. That can be established from our books; I know the 3-4 bars was not filled.

14 Q. Why was the order not filled, and in answering this question please state what, if any, efforts you made to fill it? 357

A. When the latter part of this order was received, I knew it was out of all reason for us to think of making it, as the article is not in commerce, but I thought if we could get it made I would get it made, and sent the order to parties who are in that line of business, as I thought they would give it us to serve our customers; they failed us, and therefore we were thrown on our own resources to try. I spoke to two or three of our work people, two I know whom we have yet in our employ, and they said they thought they could do it. We commenced two bars, so that if one failed we

358 should have the other, and we failed with the first one and the second one also, and we were so sure of our inability to fill the order we didn't try any more, and sent them word immediately that we could neither buy it nor make it. I wish to say further that from the date of that order unto the time that we sent them word I do not believe less than ten days elapsed; We waited a considerable time for our friends to see if they could serve us, and it was several days, I don't know how many. It took us two days at least to get the metal cast. It was that time in process, and I do not believe, take it altogether, it was less than ten days from the time we
359 received the order to the time that I sent that word.

15 Q. Were you in Europe at any time during the year 1879?

A. Yes, I went to Europe on the 14th of May.

(By consent of counsel cross-examination reserved.)

April 17th, 1882.

William Staniar recalled.

360 *Cross examination by* Mr. Betts :

16 x-Q. Did you ever have from the Weston Dynamo-Electric Machine Company any order for sheet copper or copper bars at any time, either before or after April, 1879 ?

A. We had no copper of that particular description.

17 x-Q. Do you mean to say you never had any orders from them for any sheet copper before that time, or afterwards ?

A. Of sheet copper we may have had some, but I cannot say positively now; it is barely a question.

18 x-Q. Did you ever have any order for copper bars from them at any other time ?

A. Not of that description to which I testified. 361

19 x-Q. Did you of *any* description ?

A. We had ⅜ round, and other sizes; all round.

20 x-Q. Did you ever have any orders for square copper at any other time ?

A. No, sir.

21 x-Q. But you did have orders for copper rods at other times from them ?

A. Round.

22 x-Q. Round copper rods, you did ?

A. We did have orders for round copper rods.

23 x-Q. Both before and after April, 1879 ?

A. Yes, sir.

24 x-Q. How frequently ?

A. Well, sometimes every day, sometimes twice 362
—and more—a day, sometimes, may be, not over two or three times a week. They were our regular customers in that line, and we believed that we were the only persons that served them with their copper wire.

25 x-Q. How much was the diameter of the copper rods ordered by them—the largest size ?

A. I think what we call No. 3 and 4—in that vicinity. That would be near a quarter of an inch thick; if I remember right, that was about the thickest they ever ordered.

26 x-Q. Did they order that in considerable quantities ? 363

A. Yes, sir; that with others. They had various; they varied from that down to what we call 14 and 15 wire.

27 x-Q. And they ordered these round copper bars a quarter of an inch thick, both before and after April, 1879 ?

A. I think they did. But when I speak that way, I am speaking very indefinitely—or improperly, because I am speaking from the generality of their orders. I cannot say whether these thick ones were before or after that time; but their orders were miscellaneous, you understand.

364 28 x-Q. You could always have supplied them with copper rods of these dimensions, could you ?

A. Yes, sir; that was our regular line.

29 x-Q. In how long lengths could you supply orders for copper rods quarter of an inch thick ?

A. Twenty-five pounds weight.

30 x-Q. About how long would that be ?

A. That might reach somewhere in the vicinity of 240 feet; from that to 275; somewhere about there. That is, wire in that state. That comes under the denomination of wire.

31 x-Q. You stated on your direct examination that you were not quite sure whether you filled the
365 order of April 11th for the sheet copper or not; that that could be established from your books. Have you since ascertained whether you did fill the order or not ?

A. I have not. Not being requested to do so, I took no further notice of it since.

32 x-Q. Are the Weston Dynamo Electric Machine Company customers of yours now ?

A. Only, I may say, of wire cable. They buy no wire of us comparatively.

33 x-Q. What do they buy ?

A. They buy cable—copper cable, from us.

34 x-Q. Do you remember ever filling any order
366 of theirs at any time for sheets of copper ?

A. I do not at present remember.

35 x-Q. Were you always able to fill orders for sheet copper if they desired it ?

A. Yes; marketable.

36 x-Q. Could you fill orders for sheet copper quarter of an inch thick ?

A. Yes, sir.

37 x-Q. You always have that in stock ?

A. No, sir; we buy it to order.

38 x-Q. You could always get it ?

A. Yes, sir.

39 x-Q. And as large as 14 inches square ?

A. The sheet—yes.

40 x-Q. You could have got it in 1879 ?

A. Yes, sir. 367

WM. STANIAR.

Feby. 16th, 1882.

Robert Carmichael, a witness called on behalf of Edward Weston, being duly sworn, testifies as follows:

Examined by Mr. Bailey:

1 Q. What is your name, age, residence and occupation:

A. My name is Robert Carmichael; my age 45; 368
residence, 178 Academy street, Newark, New Jersey; occupation, machinist; am employed at the factory of Roberts & Havell, and have been so employed for nearly 19 years.

2 Q. Do you know Edward Weston, one of the parties to this interference, and if so, how long have you known him?

A. I do; and have known him since 1875.

3 Q. Have you, as a machinist with Roberts & Havell, done any work on machinery or parts of machinery intended for or ordered by Mr. Weston, and if so, when did you begin to do such work?

A. I have, and began to do such work in 1875.

4 Q. Do you remember having made at any time 369
for Mr. Weston, any metallic rings, and if so, state as nearly as you can when you made them?

A. I do; they were metallic—copper and iron rings, and were made during the same week—within a week of each other.

5 Q. Which rings did you make, the copper or the iron rings?

A. The iron rings.

6 Q. Where was Mr. Weston's place of business at the time you made the iron rings?

A. In New York.

7 Q. Of what kind of iron were the rings made?

370 A. Sheet iron, about $\frac{1}{8}$ of an inch thickness and $5\frac{1}{2}$ inches in diameter with a 4-inch hole.

8 Q. Examine the rings which I hand you, marked Exhibit Weston No. 7, and state whether they resemble those which you say you made for Mr. Westton at the time named?

A. These being out of use, of course I couldn't swear whether they are the same rings or not, but they appear as much like them as anything can be.

9 Q. At the time you made those rings did you understand how they were formed and what they were to be used in or for?

A. I don't remember anything of what they were to be used for. After the rings were turned and
371 taken away from me I didn't see them any more; they were for Mr. Weston.

By consent of counsel, cross-examination reserved.

ROBERT CARMICHAEL

New York, February 23d, 1882.

Met pursuant to notice.

372 Present—

Counsel for the respective parties as before.

Abraham Van Winkle, a witness called on behalf of Edward Weston, being duly sworn, testifies as follows:

Examined by Mr. Bailey:

1 Q. What is your name, age, residence and occupation?

A. My name is Abraham Van Winkle; age 43; residence Newark, New Jersey; occupation dealer in chemicals.

2 Q. Do you know Edward Weston, and if so, 373
how long have you known him?

A. I do, and have known him since early in 1875. I was interested in the sale of the Weston machines for electro-plating and electro-typing from early in 1876; the machines being at the time constructed by Roberts & Havell of Newark, New Jersey; the manufacture being in their hands until about June of 1877. At that time a company was organized for the manufacture, and from then until early in 1881 I held the position of president of the company.

3 Q. While president of the company, do you remember meeting Professor Silliman, in a business way, if so, state about when it was and what was 374
the business which brought him to you?

A. The time was previous to our fire in Washington street. I remember, subsequently to my first meeting him at my office, corner of Market and Mulberry streets, meeting him at the factory, probably some time in 1879. That is as near as I can fix the time. The object of his visit was in relation to a machine for the Phenixville Copper Refining Company—or whatever name they had; I don't remember at present. Mr. Douglas was connected with it.

4 Q. What kind of machine?

A. That was, as near as I can remember, the
separation or refining of dark copper matte—or 375
dark copper ore, and, I think, for the object of recovering a small percentage of silver that was in it.

5 Q. It was a dynamo electric machine, wasn't it?

A. It was a dynamo electric machine, yes, sir.

6 Q. State what steps, if any, were taken to furnish this machine for the Phenixville Company, and if it was not furnished, state as fully as you can the reasons why?

A. As to what steps were taken, I cannot give anything very definite, but I can give a general reason why it was not built. It was simply that all the new construction, outside of the general machines—the regular machines that we were building,

376 was opposed by the directors of the company. There was a demand existing for what we were building, and they thought that demand could be increased without going into anything new.

7 Q. State whether or not Mr Weston was de sirous of building that machine, if you know?

Objected to as immaterial.

A. My recollection of that is limited to a conversation with Weston, in which the question of whether the copper to be used for the construction of the armature could be had—whether it was a mercantile article or not. I remember that in con-
377 nection with that I referred to a hexagon brass we were getting, which was about the same price as brass wire or rod, and that the copper of such a shape as to fit into the segments of the armature could be obtained without any increase of cost, probably. That is about the extent to which I can go into the construction of that peculiar machine. I never saw a drawing of it.

8 Q. [Question No. 7 re-read to the witness.]

A. Yes, he was, to the best of my knowledge and belief.

Cross-examination by Mr. Betts:

378 9 x-Q. You say you were president of the Weston Dynamo-Electric Machine Company till the early part of 1881?

A. Yes, sir.

10 x-Q. Wasn't it at that time known as the Weston Electric Light Company?

A. About the last year of the organization, before its consolidation and absorption by the United States Company, it was known as the Weston Electric Light Company; previous to that, as the Weston Dynamo Electric Machine Company.

11 x-Q. You speak of its absorption by the "United States Company." Do you mean the United States Electric Lighting Company?

A. Yes, sir. 379

12 x-Q. When did that absorption take place?

A. During the spring of 1881. I cannot tell you exactly the date.

13 x-Q. Are you interested in the company now?

A. Yes, sir, to a certain extent.

14 x-Q. As a stockholder?

A. Not at present.

15 x-Q. How are you interested in it?

A. Selling the machines the company make. The firm with which I am connected have the sale of the electro-plating and electro-typing machines in this country. I have the sale of the same machines in Great Britain, and am employed by the company 380
under a salary, for the sale of the electric light machines.

16 x-Q. What was the financial condition of the Weston Electric Light Company at the time it was absorbed by the United States Company?

A. The company, at that time, had paid but two dividends, and according to the books of the company they were about able to pay dollar for dollar, without any great surplus.

17 x-Q. They were in good financial condition?

A. Yes, sir; their credit was fairly good—no difficulty in paying.

18 x-Q. Had the company always been in good 381
financial condition?

A. Fairly so.

19 x-Q. Never been in debt to any considerable extent?

A. Not for any very large amount, no, sir.

20 x-Q. Had their business been improving from the time the company was originally organized in 1877?

A. Yes, sir; they were constantly improving the business; the expenses attending developing the light absorbed the profits that resulted from the sale of the plating and electrotyping machines.

21 x-Q. There was always a large demand for the electrotyping machines, was there not?

382 A. Electrotyping and electroplating, yes, sir; that has always existed, with very little decrease.

22 x-Q. Was the company ever hampered for funds in any way?

A. Yes; at times we had to use the notes of the different stockholders—discounted; they were paid, with interest. By that means we were enabled to keep right along.

23 x-Q. You had no difficulty in getting those notes?

A. None at all; and no difficulty in getting them discounted.

24 x-Q. The stockholders were always willing and
383 ready to help the company?

A. Yes; some of them were always ready to come forward when it was required.

25 x-Q. Did you ever know of any opposition on the part of the company or the directors to patenting inventions that Weston made?

A. Yes, sir; there was a general opposition to it, on the score of expense. Weston was particular as to the manner in which the specifications were drawn, and I know that our patents—the expenses attending taking out patents, were larger on account of the necessity for that extra care; and the "Scientific American" was cited, I know, on several occasions as being a cheaper source of taking out
384 patents; and they found fault frequently with the patent expenses,

26 x-Q. There was an objection, then, to the method which was adopted in taking out patents?

A. Yes, sir.

27 x-Q. And not an objection to Mr. Weston's patenting such inventions as he made, was it?

A. Well, there were at times, I think, some objections to his taking out patents; but that did not always exist.

28 x-Q. During the early years of the existence of the Weston Dynamo-Electric Machine Company was there any objection to Mr. Weston patenting such inventions as he made?

A. Well, not so much, I think, until the time of 385
the expenses attending the electric light machine construction; then, of course, our expenses were increasing very rapidly.

29 x-Q. That was at the time when the Electric Light Company was formed?

A. Yes, sir.

30 x Q. Prior to that time there had been no difficulty in that direction?

A. Yes, sir; there were objections from time to time, right along, more or less.

31 x-Q. Were there any complaints as to the efficiency of your electric typing and electroplating
machines? 386

A. At times, yes, sir.

32 x-Q. What were the sources of those complaints?

A. Well, there was a necessity, at times, for a larger machine than we were supplying; they would attempt to over-work the machines; in electrotyping, for instance, by putting on too large a surface of copper, which would heat the machines and injure the insulation.

33 x-Q. Were those complaints made during all the years of the existence of the Weston Dynamo-Electric Machine Company?

A. No, sir; they were peculiar to the last two 387
years, probably of the business.

34 x-Q. Did they exist, to some extent, before?

A. Not much.

35 x-Q. Did they at all?

A. No; I should scarcely think so. You see, the machines replaced the use of batteries, and the fact of getting a mechanical source of electricity led to the increased use of electrotyping over stereotyping in many cases. The advantages were very great, for plated goods and things of that kind, produced by the electroplating process, and very much better results were obtained by electrotyping than by stereotyping, and electrotyping consequently increased,

388 and for that reason a demand for larger machines existed.

36 x-Q. You say that existed during the last two years of the existence of the company?

A. Yes, sir.

37 x-Q. If Mr. Weston had invented a larger and more efficient machine for electrotyping or electro-plating, and one which had less tendency to overheat, would it not have been a valuable addition to the business of the company?

A. There is no doubt of it.

38 x-Q. The company would have been glad to have built any such machines at any time; would
389 they not?

A. No, sir; I should hardly think so, until they had proof that such machine was all that would be expected of it.

39 x-Q. During the last two years of the existence of the company there would have been a demand for such a machine, would there not?

A. Yes; but it was difficult to prove it to the stockholders.

40 x-Q. Was there ever any attempt to prove to the stockholders that such machines could be constructed?

A. I think so; I know that the matter of large
390 machines both for electro deposition of metals and electric lighting was canvassed at our meetings on more than one occasion.

41 x-Q. Did Mr. Weston ever attempt to prove that any such machine could be constructed?

A. I don't recollect that he did, any more than in a casual way. None of the directors of the company were conversant with electrical matters, I think, besides myself and Mr. Weston.

42 x-Q. Was anything more done than that Mr. Weston claimed that if such a machine could be made it would be desirable for the company to undertake its manufacture?

A. No more, to my knowledge.

43 x-Q. You speak of yourself being familiar with

electrical matters. How long have you been familiar 391
with electrical machines?

A. Only in regard to their application to the different uses for which they were built. I have sold a great many of the machines and put them up, both here and in Europe.

44 x-Q. How long have you been engaged in selling electro-plating and electro-typing machines?

A. Since early in 1876.

45 x-Q. Has you firm always had the sale of the machines of the company?

A. They have had since June, 1876, the sale of them; previous to that there were some sold by
Roberts & Havell. the first manufacturers of them. 392

46 x-Q. And were you familiar with the demands of the country for such machines from that time on?

A. Yes, sir.

Re-direct:

47 Q. Referring to cross-question No. 41, did Mr. Weston express any doubt that he could build such a machine?

Objected to as leading.

A. No; I don't think he expressed any doubt of
his ability to construct it; he was rather conserva- 393
tive, but he is a pretty sure gentleman in making statements.

48 Q. Who were the directors who opposed building machines?

Objected to, as assuming what the witness has not stated.

A. Well, I think among those who most strongly objected to the new construction of machines were Mr. H. P. Baldwin, James Roberts and Henry Havell The objections frequently were from Mr. Baldwin; and he had considerable influence at times

394 in conducting the policy of the company; he was rather loud talking, and they would not submit it always to a vote, by which they might have carried their point.

Re-cross:

49 x-Q. Did Mr. Weston ever claim that he had constructed any more efficient machine which had less tendency to heat than the machine which the company was then making?

Objected to as irrelevant and unwarranted.

395 A. I don't know that he did, sir.

50 x-Q. You speak of Mr. Baldwin and others having made some objections to the construction of machines. Do you refer to any particular machine, or merely a general objection?

A. A general objection, I think, that existed, against departing from the construction of machines which we were then selling

ABRAHAM VAN WINKLE.

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396 Feby. 23d, 1882.

JOHN GORMLEY, a witness called on behalf of Edward Weston, being duly sworn, testifies as follows:

Examined by Mr. Bailey:

1 Q. State your name, age, residence and occupation?

A. My name is John Gormley; age 33; residence Watertown, New York; occupation nickel plater.

2 Q. Do you know Edward Weston, if so, how long have you known him?

A. I do, and have known him for 14 years.

3 Q. Were you ever in Mr. Weston's employ, and if so, when, where, and for what length of time?

A. I was in his employ from the year 1873 to the year 1876, in the firm of Harris & Weston; also the firm of Warner & Weston. 397

4 Q. What was your occupation during your employment with the firms mentioned?

A. Electro plater; and I also assisted Mr. Weston in experiments on dynamo electric-machines.

5 Q. When did you last assist Mr. Weston on dynamo-electric machines?

A. In the year 1875; before he went to Newark.

6 Q. Do you recall any features of construction which were used in the experiment referred to in your preceding answer?

A. I can.

7 Q. State what you remember about the machine? 398

A.. I do no not know the dimensions of said machine. The machine was a small one, with three magnets and an armature; armature wound horizontally—that is, end to end, on a shaft encased in wood, with iron rings insulated from the shaft on the wood, with a copper disk on one end, commutator on the other.

8 Q. What was the armature wound with?

A. Copper wire insulated with a coating of cotton thread.

9 Q. To what were the wires connected?

A. To the copper disk on one end and commutator on the other. 399

10 Q. Where did you see this machine used?

A. At Mr. Weston's laboratory.

11 Q. Where was that at the time?

A. On Canal street, New York City.

12 Q. (Handing paper to witness). Examine the sketch marked Exhibit Weston No. 1, which I now hand you, and state whether you recognize the machine there represented?

A. I do.

13 Q. What is that machine?

A. An electric machine.

14 Q. What do you recognize it to be?

400 A. As a machine that I assisted Mr. Weston in experimenting with.

15 Q. You mean the machine referred to in your previous answer?

A. Yes, sir.

Cross-examination by Mr. Betts:

16 x-Q. When did you leave the employ of Mr. Weston?

A. In the year 1876.

17 x-Q. What part of the year 1876?

401 A. The latter part of the year 1876.

18 x-Q. What month?

A. I do not remember the month.

19 x-Q. Where were you up to the latter part of 1876?

A. In the employ of Mr. Weston at No. 180 and 182 Center street, New York City.

20 x-Q. What was his firm up to that time?

A. The firm stood as Harris & Weston—the old name stood; some people called it Warner & Weston and some Harris & Weston.

21 x-Q. In the latter part of 1876 where did you go?

A. To Yonkers, New York.

402 22 x-Q. Into whose employ?

A. The Eagle Pencil Company.

23 x-Q. How long did you remain with them?

A. Five or six months.

24 x-Q. And into whose employ did you next go?

A. Sommers, Brothers, of Brooklyn, New York.

25 x-Q. What was their business?

A. Manufacturers of dies, presses and brass-work.

26 x-Q. What did you do when with them?

A. Nickel-plater for them.

27 x-Q. What year and what month of the year did you go to Sommers, Brothers?

A. I do not remember.

28 x-Q. Can you state the year?

A. 1877, as near as I can get to it. 403

29 x-Q. Are you sure about that year?

A. I won't be sure.

30 x-Q. Why can you not be sure about that?

A. If I told you that it would be to go into my own private affairs.

31 x-Q. What objections have you to going into your own private affairs so far as is necessary to fix the time?

A. My mind was upset at that time, so that I cannot place the dates.

32 x-Q. What do you mean by your mind's being upset?

A. Well, my mind was on something else at the time. 404

33 x-Q. How long did you stay with Sommers, Brothers?

A. Six weeks.

34 x-Q. Where did you next go to?

A. I went to Wappinger's Falls.

35 x-Q. What year was that?

A. 1878.

36 x-Q. Into whose employ did you go there?

A. Brown, Brothers, comb manufacturers.

37 x-Q. And what was your business with them?

A. Nickel plater.

38 x-Q. Did you go directly from Sommers, Brothers to Wappinger's Falls? 405

A. I did not.

39 x-Q. Where were you employed in the mean time?

A. I was in several places for a short time—a very short time.

40 x-Q. With whom and where?

A. I think the company was the Boston Nickel Plating Works on Centre street, New York.

41 x-Q. When were you with them?

A. In 1878.

42 x-Q. Are you sure it was in 1878?

A. I won't be sure, but I think it was, to the best of my knowledge and belief.

406 43 Q. May it have been later?

A. I think 1878, sir.

44 x-Q. Have you any means of fixing that time?

A. I have means of fixing the time.

45 x-Q. Can you fix it any nearer?

A. I cannot at the present time, not having the notes or letters with me which I made at the time.

46 x-Q. Who else were you with before you went to Wappinger's Falls?

A. I went to assist a young man who had started the nickel plating business on Gold street.

47 x-Q. Who was the young man?

A. I don't remember his name, sir.

407 48 x-Q. How long did you stay with him?

A. I was not in his employ.

49 x-Q. How long did you assist him?

A. On several occasions.

50 x-Q. What year were you with this young man?

A. I think the same year—1878.

51 x-Q. Are you sure that was not 1879?

A. I think not.

52 x-Q. I asked you if you were sure?

A. Yes.

53 x-Q. Who else were you with before you went to Wappinger's Falls, after leaving Sommers, Brothers?

408 A. No one, sir.

54 x-Q. What part of 1878 did you go to Wappinger's Falls?

A. In the Summer of 1878.

55 x-Q. Do you remember the month?

A. I do not.

56 x-Q. How long did you stay with Brown, Brothers at Wappinger's Falls?

A. Two or three months!—two months, I think it was.

57 x-Q. Then where did you go to?

A. To New York.

58 x-Q. Into whose employ?

A. No one's employ, sir.

59 x-Q. How long did you remain out of employment? 409

A. Two or three weeks.

60 x-Q. And then what did you do?

A. Went to Watertown, New York.

61 x-Q. In what year was that?

A. 1879.

62 x-Q. What part of 1879?

A. October, 1879.

63 x-Q. Into whose employ, did you go at Watertown?

A. The Eames Vacuum Brake Company.

64 x-Q. How long did you remain with them?

A. I am with them at the present time, sir—in their employ. 410

65 x-Q. How do you know it was in 1876 that you left the employ of Mr. Weston?

A. A little business transaction that occurred in the firm, that brings it to my mind.

66 x-Q. What was the business transaction?

A. Mr. Weston wanted me to quit the firm and go somewhere else.

67 x-Q. Why?

A. Because I wanted to go.

68 x-Q. Why did you want to go?

A. I did not like the Mr. Warner who was in the firm. 411

69 x-Q. How do you know that was in 1876?

A. Because my memory tells me it was.

70 x-Q. Have you anything definite to fix that time in your memory?

A. Yes, lots; too numerous.

71 x-Q. What?

A. I might tell you a thousand things on that.

72 x-Q. State the most prominent things?

A. For the reason that Mr. Warner would get no supplies to carry on his business; because Mr. Warner drank too much whiskey to attend to his business.

73 x-Q. How does that enable you to fix the year?

412 A. By Mr. Warner's transactions.

74 x Q. What connection had these transactions with the year 1876, rather than any other year?

A. Because, when I was in the employ of Mr. Weston, and Mr. Weston had charge of the works, he would always furnish supplies to keep the works, going.

75 x Q. How do you know it was in 1876, rather than in 1877?

A. Previous to that time we always had lots of work and got our money regular, which we did not when Mr. Warner had it, in 1876.

76 x-Q. I want to know why it is that you say
413 this happened in 1876, rather than 1877?

A. I was not in the employ of the firm in 1877.

77 x-Q. How do you know?

A. Because I was in the employ of another firm.

78 x-Q. What other firm?

A. Sommers, Brothers.

79 x-Q. Is that your only reason for fixing the year?

A. That is all, sir.

80 x-Q. You have spoken about an experiment in 1875. How do you know it was in 1875?

A. That was previous to the time that Mr. Weston went to Newark. Mr. Weston was not in the
414 shop as much as he had been previous to that time.

81 x-Q. How do you know it was previous to his going to Newark?

A. Because Mr. Weston at that time was engaged on a nickel plating case, in a suit of the New York Nickel Company *vs.* Harris & Weston, I believe it was.

82 x-Q. What connection is there between that case and this experiment?

A. Which experiment do you refer to?

83 x-Q. I mean the experiment that you referred to, which you say was made in 1875?

A. It had nothing to do in relation to that, sir.

84 x-Q. Then how does the fact that Mr. Weston

was engaged in that case enable you to fix the 415
date?

A. Because, Mr. Weston being away, I had charge of the inside work of the company.

85 x-Q. Mr. Weston was away when?

A. Several times from 1873 to 1875.

86 x-Q. Was he ever away afterwards?

A. He was.

87 x-Q. Why then do you say that this experiment took place in 1875?

A. Because I know it took place in 1875; Mr. Western experimented in the evenings in his laboratory.

88 x-Q. Didn't he experiment in the evenings in 416
other years?

A. No, sir, he did not.

89 x-Q. Are you positive about that?

A. I am not positive; I will alter that, because I was not there with him and assisting him previous to that time.

90 x-Q. How do you know it was 1875 that he used to go to his laboratory in the evenings?

A. That was the time he was experimenting on this machine; previous to that machine he experimented in the shop.

91 x-Q. Did you ever see more than one experiment at his laboratory?

A. I have. 417

92 x-Q. How many have you ever seen?

A. Several.

93 x-Q. Can you describe any other one?

A. Any other experiment?

94 x-Q. Yes.

A. Yes, sir; an experiment with nickel plating solutions.

95 x-Q. Did you ever know of his experimenting with any other kind of machine than the one which you referred to?

A. Yes, sir.

96 x-Q. When was it?

A. In 1873.

418 97 x-Q. Where was it ?
A. Elm street, New York.
98 x-Q. Did you ever know of his experimenting with any other machine at his laboratory ?
A. Not as I know of.
99 x-Q. How many times did you ever go to his laboratory ?
A. Several times.
100 x-Q. Well, how many times ?
A. Probably one hundred times.
101 x-Q. During what years ?
A. 1875—1874 and 1875.
102 x-Q. And 1876 ?
419 A. No, sir.
103 x-Q. What did you have to do with this machine that you say you saw in 1875 ?
A. Aided and assisted Mr. Weston in doing some work on a lathe.
104 x-Q. What was the work that you did ?
A. Some mechanical work.
105 x-Q. What mechanical work ?
A. Boring pieces of iron and making battery attachments.
106 x-Q. Was that on this machine which you have described in your direct evidence ?
A. No, sir.
107 x-Q. Did you ever work on that machine that
420 you have described in your direct evidence, at all ?
A. I have.
108 x-Q. What did you do about that ?
A. In aiding Mr. Weston to wind the armature.
109 x-Q. Did you do that more than once ?
A. I did ; several times.
110 x-Q. Always doing the same thing ?
A. Not in winding the armature.
111 x-Q. What other work did you do on that machine which you described in your direct testimony besides assisting to wind the armature ?
A. Turning the lathe for him ; working the lathe.

112 x-Q. Was that in the process of making the 421
machine ?
A. Yes, sir.
113 x-Q. Did you ever do anything else about it ?
A. No, sir.
114 x-Q. How many times did you see this machine ?
A. Several times ; I cannot tell you how many times.
115 x-Q. Well, more than twice ?
A. Yes, sir.
116 x-Q. When was it that you saw it, in the evening or day time ?
A. Evening.
117 x-Q. Always in the evening ? 422
A. Yes, sir.
118 x-Q. Can you remember the season of the year when you saw it ?
A. Yes, sir ; the Summer of 1875.
119 x-Q. How do you know it was Summer ?
A. On account of the warm weather.
120 x-Q. Did you ever test the machine at all ?
A. I never tested the machine, sir.
121 x-Q. Did you ever assist at any test ?
A. Yes, sir.
122 x-Q. What did you do ?
A. Turn the foot lathe for Mr. Weston.
123 x-Q. How was the machine to be tested ? 423
A. By getting power through the lathe. Mr. Weston had wires attached on two pieces of copper on the commutator.
124 x Q. Wont you explain more fully what was done with the machine so tested ?
A. The wires were attached to the machine, and Mr. Weston attached two pieces of small sheet copper on to those wires and placed them on the commutator, to see if he could derive a spark from the machine.
125 x-Q. Was that the only test that you remember ?
A. That is all, sir, that I remember.

424 126 x-Q. Could he get a spark from the machine?
A. A faint one.
127 x-Q. Very faint?
A. So you could discern it.
128 x-Q. How long did this test last?
A. I do not know, sir.
129 x-Q. Did you ever see it again?
A. Not as I know of.
130 x-Q. What did Weston say about this experiment?
A. I heard him say nothing in regard to it?
131 x-Q. Didn't he express any opinion about it?
A. No, sir, he did not.
425 132 x-Q. You spoke of this machine of 1875 having a disk on one end of the armature. What was the size of the disk?
A. I should judge about five inches in diameter.
133 x-Q. Do you remember the thickness of the copper?
A. Well, I should judge about $\frac{1}{8}$ of an inch thick.
134 x-Q. Before you testified in this case to-day, was the testimony of Mr. Weston read over to you?
A. It was not.
135 x-Q. Did you read it yourself?
A. I did not.
136 x-Q. Do you know what he has testified to in this case?
426 A. I do not.
137 x-Q. How many field magnets were there in this machine?
A. One
138 x-Q. Give the dimensions of that?
A. I cannot.
139 x-Q. Can you give me anywhere near the size of that field magnet?
A, No, sir; I can say it was small—not diminutive.
140 x-Q. After you were present at the test of the machine which you say you saw in 1875, were you ever at Mr. Weston's laboratory again?
A. I was.

141 x-Q. Often? 427
A. No.
142 x-Q. About how often?
A. I cannot say.
143 x-Q. Did you continue to go there all the time until you left his employ?
A. I did not.
144 x Q. Why not?
A. Mr. Weston was not there.
145 x-Q. As long as he was there, did you continue to go there?
A. I did.
146 x-Q. Did you ever see any parts of this 1875 machine subsequently? 428
A. I did not.
147 x-Q. Where were your regular duties at that time—in 1875?
A. At the Nickel Plating Works on Centre street, New York.
148 x-Q. Do you mean Harris & Weston's?
A. Yes, sir.
149 x-Q. What were your duties at the Nickel Plating works?
A. To see to the nickel plating; also to the management of the polishing room and plating room.
150 x-Q. Was this machine which you say you saw in the laboratory ever brought to the Nickel Plating Works? 429
A. I cannot remember that it was; I know there was a machine there, but I cannot say as to its being that machine.
151 x Q. What was your position with reference to the other people who were in the employ of Harris & Weston—were you in charge?
A. I was in charge.
152 x-Q. Of the Nickel Plating Works?
A. Yes, sir.
153 x-Q. Can you remember the particular occasion when you first saw this machine in 1875?
A. I cannot.

430 154 x-Q. What was the first thing you had to do with it?

A. Uncoiling the wire for Mr. Weston.

155 x-Q. What were you uncoiling the wire for?

A. In order to form it on the armature.

156 x-Q. What did you uncoil it from?

A. From a coil of wire that was lying on the floor.

157 x-Q. Did you coil it on the armature?

A. No, sir.

158 x-Q. How long were you engaged about that?

A. One night—or one evening; part of the evening.

431 159 x-Q. Well, how long altogether?

A. O, I should say 8 to 10 hours.

160 x-Q. Did it take that length of time to wind the armature?

A. No, sir—I don't know whether it did or not; I did not stay there.

161 x-Q. Then you were not engaged eight or ten hours entirely at this work?

A. Not at one time.

162 x-Q. How long were you so engaged on this first occasion of which I asked you?

A. Three or four hours.

163 x-Q. Why did it take so long a time?

A. Mr. Weston was thinking of something else.

432 164 x-Q. What else?

A. I don't know.

165 x-Q. How much of the machine was finished at that time?

A. Just winding the armature.

166 x-Q. Nothing else was done?

A. No, sir.

167 x-Q. Was there any disk on the end of the armature at that time?

A. There was.

168 x-Q. How was it fastened to the armature?

A. Soldered on one side to the copper disk.

169 x-Q. You mean the armature was soldered to the copper disk?

A. I mean the wires were soldered to the copper disk. 433

170 x-Q. On one side?

A. Yes, sir.

171 x-Q. And how was the copper disk fastened to the armature?

A. Fastened with the wires on this wooden insulation.

172 x-Q. What made it remain on the armature?

A. By the wires being attached to it.

173 x-Q. You say they were soldered on one side only?

A. Yes, sir.

174 x-Q. How many wires were there that were soldered? 434

A. There might be 30; there may be 40; I cannot tell the exact number.

175 x-Q. What was Mr. Weston doing to the armature at that time?

A. Soldering the ends of the wires to said disk.

176 x-Q. How long were these wires?

A. I do not know.

177 x-Q. About how long?

A. I have no idea.

178 x-Q. Six inches or five yards?

A. Probably six or eight inches long.

179 x-Q. What was the next occasion when you saw this machine? 435

A. I visited with Mr. Weston on another evening after that.

180 x-Q. Was that the occasion when you helped on the lathe?

A. Yes, sir.

181 x-Q. Was the machine finished then?

A. It was.

182 x-Q. Then were those two occasions the only occasions when you saw it?

A. Two occasions; that is all, sir.

183 x-Q. How long did you see it on the second occasion.

A. I don't remember, sir.

436 184 x-Q. Do you remember how long you were engaged in turning this lathe?

A. No, sir, I do not.

185 x-Q. About how long?

A. Probably half an hour.

186 x-Q. Did the experiment seem to be satisfactory to Mr. Weston?

A. I don't know.

187 x-Q. When did you come from Watertown?

A. Last Sunday morning.

188 x-Q. At whose request did you come?

A. Mr. Weston's request.

189 x-Q. Did you know what you were coming
437 for?

A. I did not; it was on a case previous to this.

190 x-Q. How long is it since you have had any occasion to think of this machine of 1875?

A. Two weeks ago.

191 x-Q. What happened then?

A. I got a letter from Mr. Weston.

192 x-Q. Before two weeks ago, had you had any occasion to think of it since 1875?

A. I did not.

193 x-Q. *Had* you ever thought of it since 1875, to your knowledge?

A. Previous to that time?

438 194 x-Q. Yes.

A. I did not.

Re-direct:

195 Q. You say that wires were soldered on one side; on one side of what?

A. Of the copper disk.

196 Q. How have you been engaged, or what have you been engaged on, since you came to New York last Sunday?

A. In a suit relating to the electro-plating of copper on carbon.

197 Q. How have you been engaged there?

A. By giving testimony.

Re-cross: 439

198 x-Q. Were you testifying on behalf of Mr. Weston in said suit relating to the electro-plating of carbons?

A. Yes.

199 x-Q You said that the wires were soldered on one side of the copper disk. Won't you explain a little more fully how they were soldered?

A. I don't remember.

200 x-Q. Cannot you tell us anything about that?

A. No, sir; all I know that the wires were soldered to the copper disk; I cannot tell you in what way they were bent, or how they were? 440

201 x-Q. Do you know whether they were bent over on to one side of the disk and soldered on the side or not?

A. I don't remember how they were bent, or whether they *were* bent; whether they came out straight right from the armature, or how; I could not tell you, sir.

202. x-Q. Were they soldered all round the copper disk?

A. They were.

203 x-Q. Close together?

A. Close together; that is, spaced off; I cannot tell you how near nor how far they were apart?

JOHN GORMLEY. 441

PRINTED COURT RECORDS

Seyfert v. Edison (1880)

This 14-page pamphlet contains testimony given by George Harrington, Josiah C. Reiff, and Lucy F. Seyfert between September and December 1882 in a civil suit involving Edison and Seyfert. Mrs. Seyfert was the widow of William M. Seyfert, an investor in the Automatic Telegraph Company. She initiated the suit in November 1880 in order to obtain payment on a promissory note signed by Edison on December 9, 1874. Harrington, who at the time was president of the Automatic Telegraph Company, was the original recipient of the note. It was subsequently signed over to Seyfert as part of a business arrangement regarding Edison's automatic telegraph patents. A copy of the note is included in the printed record. The jury subsequently awarded Mrs. Seyfert a judgment of $5065.84.

Edison, T.A. - Personal - (1882)

W. S. Sharp Printing Co., 21 W. State Street, Trenton, N. J.

NEW JERSEY SUPREME COURT

LUCY F. SEYFERT

vs.

THOMAS A. EDISON.

In Case.

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W. S. Sharp Printing Co., 21 W. State Street, Trenton, N. J.

NEW JERSEY SUPRFME COURT

LUCY F. SEYFERT vs. *THOMAS A. EDISON.* } *In Case.*

This suit was brought by Lucy F. Seyfert against Thomas A. Edison, and the summons returned in the term of November, eighteen hundred and eighty, of Supreme Court.

The declaration, in the ordinary form, on the note hereinafter mentioned, and plea *non assumpsit* and issue joined.

COPY OF NOTE.

$3351.70. New York, Dec. 9, 1874.

Three months after date I promise to pay to the order of Geo. Harrington, three thousand three hundred and

fifty-one $^{70}/_{100}$, at office of Messrs. E. D. Randolph & Co., in New York. Value received.

Due March 9, 12, '75.

THOMAS A. EDISON.

Endorsed—Geo. Harrington.

On December 18th, 1882, this cause was regularly moved for trial before Mr. Justice Scudder, at the Middlesex Circuit.

A. H. Strong appearing for plaintiff, G. D. W. Vroom and M. Beasley, Jr., for defendant.

Plaintiff offered in evidence the note dated December 9th, 1874.

e/ The signatures of the maker and the payee of the note were admitted.

The note was read to the jury, when the plaintiff rested.

The defendant then read the following depositions taken in the above cause:

DEPOSITIONS.

George Harrington, a witness produced in behalf of the above defendant, being duly sworn according to law, on his oath deposes and says—

I reside at Washington, in the District of Columbia; in the years 1872, 1873, and 1874, I lived principally in New York city; I know Thomas A. Edison, the defendant in this case, very well; during the time above mentioned I was connected in business with Thomas A. Edison; others, quite a number, were associated with us; I know William M. Seyfert; he was among those who were associated with us at that time; he then lived in Philadelphia, and was of the firm of Seyfert, McManus & Co.; this association was for the purpose of aiding Edison in the development of his telegraphic inventions for our mutual benefit; Edison then lived at Newark, New Jersey, and his factory and place of business was,

also, in Newark; in the year 1874 Thomas A. Edison was embarrassed financially; he had had a partner in the manufacturing of instruments, but from whom he had separated; in the settlement with that partner there was an amount due him, the partner, which Mr. Edison could not at that time pay, and he gave to the partner a lien upon his factory as security; that lien was in the nature of a mortgage, as I understood; Mr. Edison at that time called upon me and my associates for assistance; this was late in the year 1874; he stated to us that the debt to his former partner had matured, and that unless the debt was satisfied they would levy on his factory; that he must have some money, and that if we could not furnish it he could get the necessary amount from the Western Union company; to do so he would be obliged to give to that company rights upon certain telegraphic inventions of his which it was important for us to prevent; we communicated the condition of affairs to Mr. Seyfert, and requested him to provide the requisite sum, in the same manner as he had provided other sums, as subscriptions to the undertaking in which we were jointly interested; Mr. Seyfert came to New York and brought with him some bonds which he left with us, upon which to raise the money in New York city; it was then arranged that we should give to him accommodation notes that he could use in Philadelphia, if he so desired; these accommodation notes were given; I don't remember whether at that time in that particular transaction there was more than one note, but other notes had been given with the distinct understanding that if used Mr. Seyfert was to take them up at maturity; the proceeds of such notes, as well as the money raised upon the bonds that he left with us, were considered as subscriptions to the enterprise, and the amounts thereof were entered upon the books of the associates to the credit of Seyfert, McManus & Co. principally, the firm I have above spoken of, with which Mr. Seyfert was connected; it was distinctly understood between the par-

where are these books? [illegible]

ties that these were accommodation notes, which were to be provided for by Mr. Seyfert, or Seyfert, McManus & Co., if used.

[Paper shown witness, he says]—That is one of the notes above spoken of, drawn in my handwriting, and signed by Thomas A. Edison; it is drawn to my order and endorsed in blank by myself, Mr. Samuel B. Parsons, and Josiah C. Reiff, and given to Mr. Seyfert; this note is one of the accommodation notes I have just spoken of and is the note upon which suit in this case has been brought; Seyfert, McManus & Co. sent to New York, or Mr. Seyfert sent to New York for the firm, for himself and for Mr. McManus individually, their clerk with a list of all their payments on account of this enterprise; I should say that soon after the giving of this note upon which suit has been brought, an agreement was made by Mr. McManus and Mr. J. C. Reiff on the part of the associates, and Mr. Jay Gould on the part of the Atlantic and Pacific Telegraph Company, for the transfer to the Atlantic and Pacific Telegraph Company for a specified sum all the rights, title, and interest of the associates in and to the inventions of Thomas A. Edison, and when under this agreement the books of the association were finally made up, thereby showing the separate interest of each of the associates with a view to the *pro rata* division of the proceeds of the sale to the Atlantic and Pacific Telegraph Company, under the agreement before referred to, the clerk of Seyfert, McManus & Co. came to New York with a list of credits claimed by that firm, which list included the proceeds of those bonds, and all accommodation notes where money had been advanced by that firm to the enterprise; the clerk examined the books and the accounts therein set forth, of Seyfert, McManus & Co., John McManus and William M. Seyfert, and found the credits on the books to correspond precisely with the list brought by him, the clerk; that sale has not yet been settled; had it been, or when it

shall be settled, Seyfert, McManus & Co. will receive therefrom payment for all their advances.

Being cross-examined, deponent says—

When Mr. Edison called on me, that is, meaning by "me" the associates, he applied to Mr. Reiff and myself; on that particular occasion I don't remember who notified Mr. Seyfert; the notice emanated from Mr. Reiff and myself, but the manner of the communication I do not remember; Mr. Reiff and myself met Mr. Seyfert in New York when he brought the bonds; he came to our office; I was present at the whole interview; so far as I remember it was all settled at that time with reference to this particular note now sued on; no receipt was given to Mr. Seyfert that I remember; I do not know the amount raised on those bonds; that was attended to by Mr. Reiff; he was the general agent of the associates for the purpose of raising money for them; he was the cashier; between the giving of this note and the delivery of those bonds there was this connection, the bonds were brought to New York in order that money might be raised there, and thus relieve Mr Seyfert to that extent of using the Philadelphia money market, and we were to give him this note payable in New York, which he could get discounted in Philadelphia more easily than he could his own notes; this note sued on was given on the same day the bonds were delivered, if I remember rightly; it was given to Mr. Seyfert; by whom I don't remember; the different signatures on the note which I have mentioned were procured by either Mr. Reiff or myself, I don't recollect which; we were there all together; I don't remember whether this note represents the proceeds, or the amount of the proceeds of the sale of the bonds; for that information I refer you to Mr. Reiff, who was conversant with all the transactions of the associates; I do not remember whether that note was a renewal of a previous note; they were accommoda-

tion notes, several of them; Mr. Reiff can give all the details.

Q. Then, if I understood you, there was no connection between the delivery of the bonds and the giving of this note?

A. I must refer you to Mr. Reiff; I can't say what the connec ion is, if any; at the time of this transaction I don't remember whether there was any statement in writing of the terms of the transaction given to Mr. Seyfert; Mr. Reiff could probably tell; whether the bonds belonged to Mr. Seyfert individually, or to the firm of which he was a member, I do not know; at the interview between Mr. Seyfert, Mr. Reiff and myself when the bonds were given up, I can't remember the details of what took place; the arrangement was perfected; I don't remember the amount of the bonds, nor the kind of bonds they were; I suppose Mr. Reiff would recollect more particularly, because he had the special charge of this matter; Mr. Reiff undoubtedly had other interviews with Seyfert, but not, I think, with reference to this transaction; Mr. Seyfert came to New York, settled the business the same day, and went back to Philadelphia, and therefore could not have had a separate interview with Mr. Reiff; this transaction was at or about the date of the note, so far as I recollect; I think it was at or about the date of the note; I can give no other reason for it but the facts which I have stated on my direct examination; I identify this note as the one given when the bonds were delivered by the fact that it was about the date the bonds were used to meet Mr. Edison's demands, and the note being signed by Mr. Edison; the notes were not usually signed by him; I don't remember whether this was the only one so signed by him; the prominent facts I can give; for the details I must refer to Mr. Reiff; my impression is that the amount which it was necessary for Mr. Edison to raise, was approaching $10,000, but I cannot state positively; I don't remember whether the proceeds of the bonds

why 2-1-74
p 3

satisfied the amount needed by him; I can't answer whether the proceeds of this note went to relieve Mr. Edison; I do not know what they went for.

GEO. HARRINGTON.

Sworn to and subscribed before me, a master in chancery of New Jersey, at the city of New York, in the State of New York, on the 19th day of September, A. D. 1881.

JAMES BUCHANAN, *M. C.*

Josiah C. Reiff, a witness produced on the part of the defendant, being duly sworn according to law, deposes and says—

I live in the city of New York; I know the defendant, Thomas A. Edison; I was associated with Mr. Edison in business; I was associated with Mr. Edison for the purpose of developing certain telegraphic and electric inventions; the principal associates were Seyfert, McManus & Co., Mr. George Harrington, H. C. Dallett, Jr., and several others; this was in the year beginning 1870, and extending until 1875, under the special arrangement including the above-named parties.

Q. Was Mr. Edison, in the year 1874, embarrassed in any way, financially?

A. Mr. Edison had a mortgage upon some machinery maturing during the summer of 1874, amounting to some $10,000, the maturing of which caused him, as he informed me, great anxiety.

Q. Was any arrangement made to assist Mr. Edison by yourself and others at that time.

A. Yes, sir; Mr. Edison acquainted Mr. George Harrington and myself with his position and the immediate necessity for liquidating this mortgage; we conferred with our associates, especially with Mr. William M. Seyfert, Mr. H. C. Dallett and Mr. Samuel B. Parsons; there was no money due by them to Mr. Edison, and the panic of the fall preceding had placed us all in

position of not desiring to incur any unnecessary responsibility, but our interests were so large in connection with Mr. Edison, and the relations sustained by our interests to those of the Western Union Telegraph Company, both on account of the inventions being developed and of the relation of Mr. Edison with the Gold and Stock Telegraph Company, which was under the control of the Western Union Telegraph Company, it became of great importance to sustain Mr. Edison's credit, inasmuch as the Western Union company had proffered the needed assistance to Mr. Edison, in the hope that they could thereby complicate his relations to us and the title to certain of his inventions which they were anxious to control; Mr. Seyfert finally agreed to advance to us certain bonds which he held, upon which little or no money could be borrowed, but which could be sold at a price; this upon the understanding that the proceeds should be credited to him upon the books of the associates as if the amount had been originally subscribed, it being considered at that time that the subscription basis would result in considerable profit; the proceeds of these bonds, with certain notes and other moneys raised by me and given to the party holding the mortgage, resulted in liquidating the mortgage and relieving not only Mr. Edison, but all of us associated with him; Mr. Seyfert thereupon urged that, as he had accommodated the general interest, we should in return aid him, which he said could be done by giving him some of Edison's paper, endorsed by Harrington, Parsons and myself, which he could have discounted in Philadelphia, and he agreed that if the notes were so given and were made to run four months, which would make them negotiable, he would take them up at maturity by renewal, and so carry them along until certain negotiations were completed, by which the associate interest would realize on the inventions, when the various accounts growing out of subscriptions and otherwise would be settled; it was understood, of

course, that Mr. Edison should not be called upon to provide for this paper, as Mr. Seyfert was to be credited with the proceeds of his bonds, as I was to be credited with the moneys I provided in addition to meet the necessity; in the final settlement the associates would have charged Mr. Edison with the amount advanced, unless it should have become due him by subsequent work done before the inventions were realized upon. [Paper shown witness]—This, I take it, is the first renewal of the note in accordance with the understanding heretofore referred to; payment for this note was not, to my knowledge, at the time of its maturity demanded, either from Mr. Edison or either of the endorsers, Harrington, Parsons or myself, and for the reason that the expected negotiation of the inventions had meantime been made with Mr. Jay Gould for the Atlantic and Pacific Telegraph Company, and the final settlement for the same was then about being made; about the same time the accounts of the associates had been made up, under the specific care of Mr. Harrington, and submitted to the principal associates, including Seyfert, McManus & Co., and the confidential book-keeper of the firm had come to New York, examined the accounts, and made an extract of the same, in which appeared the due credit to Mr. William M. Seyfert for the proceeds of the aforesaid bonds, exclusive of the amount due the firm of Seyfert, McManus & Co. [Mr. Strong objected to all evidence by the witness relating to the contents of the accounts, or of any extracts therefrom]. The extract of the account before referred to, as made by Seyfert's book-keeper, was taken to Philadelphia, and, I presume, is now in the possession of Mr. Seyfert, he, as well as his partner, Mr. McManus, having approved the same to me orally.

Q. What was the understanding in reference to the character of this note; was it to be considered as an accommodation paper?

A. Absolutely so, and when the accounts were ad-

justed, as already stated, this was esteemed to be canceled, and should have been surrendered by Mr. Seyfert, as it undoubtedly would have been, had it been deemed important to have demanded it at that time; but it, like various matters in the hands of the various parties in interest, was allowed to lie over until the final settlement of all matters with the Atlantic and Pacific Telegraph Company should be consummated as then pending; I presume that this is a renewal of the first note given to Mr. Seyfert; the body of this note is in the handwriting of Mr. George Harrington, signed by Mr. Edison, and endorsed by George Harrington, Samuel B. Parsons and Josiah C. Reiff; the proceeds of this note did not, to my knowledge, go to Mr. Edison.

Cross-examined by Mr. Strong—

The bonds advanced by Mr. Seyfert were known as land bonds, based, as I understood, upon certain coal or iron lands in Pennsylvania; I think the par value of the bonds advanced was $9000 or $10,000; as nearly as I can now recollect, the amount realized upon these bonds was between fifty seven and sixty per cent., and Mr. Seyfert was credited, I think, with $6000—possibly with $6600; at the time of the coal bond transaction, my impression is that there were two notes given; I think they were similar in all respects; the aggregate amount of the two notes was the amount, I remember, agreed upon with Mr. Seyfert to be credited to him as a subscription.

Q. What other security for the return of his money or the payment of the sum agreed upon for these bonds was Seyfert to have other than his interest in the pool?

A. None; my impression is that this mortgage of Edison's, to which I have alluded, fell due early in July, 1874; my impression is that we received the bonds from Mr. Seyfert in the latter part of June, and were several days in finding a market for the bonds; the payment of the mort-

gage was not completed on the exact day of maturity, I having secured from the holder a brief extension, by the payment of a certain amount on account, and some interest which was due; I do not remember exactly the price realized for the bonds, but I think that Mr. Seyfert considered the price inadequate, and we consented that the credit should be somewhat in excess of the amount actually realized; in this matter I was the treasurer of the associates, and this arrangement with Mr. Seyfert was arrived at especially through Mr. Harrington, Mr. Parsons and myself; there were no other notes given to Mr. Seyfert by Mr. Edison, endorsed by Harrington, Parsons and Reiff, except the original notes given, and any given in renewal, to my knowledge; there was no other transaction with Mr. Seyfert in land bonds, to my knowledge; there never was, at any time, any different arrangement with Mr. Seyfert in reference to the bonds, other than the one I have referred to, made by me or with my knowledge; the terms of the arrangement were never reduced to writing by me or to my knowledge; the arrangement was an oral one, after conference between Seyfert, Harrington, Parsons and myself; the paper which Seyfert was to have discounted in Philadelphia was for his benefit; it was not considered as a further subscription to the associate interest; I assume this renewal note, which I hold in my hand, to be similar, in all respects, to the one for which it was given in renewal; in substance it is the same, as to purpose, signature and endorsements; I do not remember what became of the original note—probably destroyed.

JOSIAH C. REIFF.

Sworn and subscribed to before me, a master in chancery of New Jersey, this 11th day of September, A. D. 1882.

RUTHERFORD COLEMAN, *M. C.*

Lucy F. Seyfert, a witness produced on the part of the defendant, being duly affirmed, alleging herself conscientiously scrupulous of taking an oath, saith—

I reside at No. 1849 North Eleventh street, in the city of Philadelphia; I am the wife of William M. Seyfert, of the city of Philadelphia; I am the plaintiff in the above suit; this has been brought upon a note of Thomas A. Edison's; I am the owner of that note; the date of that note is December 9th, 1874; this I ascertain by referring to a memorandum of my own.

Q. When was the memorandum which you refer to, and from which you obtain the date of the said note, made?

A. The memorandum was made as far back as 1875.

Q. Were you the owner of that note at the time of making the memorandum which you refer to?

A. Yes.

Q. From whom did you get the said note, and where?

A. From my husband.

Q. What were the circumstances under which you came into possession of that note?

A. Money which my husband borrowed from me at different times.

Q. Was the note passed into your possession?

A. I had it for a long time.

Q. Do you know whether it was before or after the note was protested that it came into your hands?

A. I don't know anything about that.

Q. The note having been drawn payable in three months and dated December 9th, 1874, it would have been due on March 9th and 12th, 1875; can you tell whether you were the owner of the note prior to March 12th, 1875?

A. I would not be able to tell, it was such a long time; I have no memoranda by which to show it.

Q. What did you give for the note?

A. I gave money for it, and gave it at different times, and much more than the amount of the note.

Q. Was this your own money?

A. Yes.

Q. Money which you held in your own right?

A. Money that I inherited; the money was in my own possession and control when I made loans to Mr. Seyfert; Mr. Seyfert was then in business; he was a member of the firm of Seyfert, McManus & Co.; I loaned this money to him individually; I do not recollect, in the absence of the note, whether I endorsed it or not.

Q. Can you, from any memoranda that you have, approximate at all to the amount which you loaned to Mr. Seyfert prior to 1875?

A. $32,000 was the amount of my stock in the firm of Seyfert, McManus & Co.

Q. [Repeated as above.]

A. I sold a house and gave him the proceeds, which were $7500, prior to 1874; he also got my undivided interest in certain property amounting to $500, prior to 1870; he got the proceeds of stock I held in the Farmers' Bank of Reading, amounting to $1717.90; he got the proceeds of the stock of the Union National Bank which I held; this was in 1875; in May, 1865, I advanced him $1500, in cash; in addition to this he got all my stock in Seyfert, McManus & Co.'s firm; the stock was transferred in 1876.

Q. Then you claim that this note was set over to you by Mr. Seyfert in part payment of advances made by you to him?

A. Yes.

Q. Then you cannot give the date of the transfer any nearer than that it was some time in 1875?

A. Yes.

Cross-examined by Mr. Fisher.

Q. Was not Seyfert, McManus & Co. indebted to you, on or before January, 1875, for interest and dividends exceeding the sum of this Edison note?

A. Yes; almost double that amount, which has not been paid.

Q. Mr. Seyfert in 1874 and beginning of 1875 tended to your banking business for you, I believe?

A. Yes.

Q. You entrusted him with the collections of maturing paper, maturing dividends, and maturing interest at that time?

A. Yes.

LUCY F. SEYFERT.

Sworn and subscribed, before me, this 2d day of December, A. D. 1882.

ANDREW JAS. SMITH.

The court directed the jury to find for the plaintiff, and to assess the damages to the full amount of the pr n-cipal and interest of the note. The jury rendered a verdict in favor of plaintiff for $5065.84.

1 [illegible]

2 [illegible] after

maturity [illegible]

3

Edison Electric Light Company v. United States Electric Lighting Company (1885)

This infringement suit was initiated by the Edison Electric Light Company in 1885. The Edison interests claimed that the lamp patents of William E. Sawyer and Albon Man, which had been assigned to the United States Electric Lighting Company, infringed on Edison's patent for lamp filaments (U.S. Patent No. 223,898). Most of the testimony and exhibits from the earlier patent interference proceedings (Sawyer and Man v. Edison, 1881) were subsequently entered into the record of this case. Other testimony was heard in 1889 and 1890, and the appeal was argued in 1892. Depositions and exhibits from two other cases (the McKeesport Case and the Trenton Feeder Case), which were initiated at a later date but decided while this case was still being heard, were also entered into the record. The events detailed by the testimony and exhibits all occurred between 1878 and 1882. The original bill of complaint, filed in 1885, is bound with the patent interference (see Miscellaneous Bound Interferences). The Digest of Proofs and Index, which precedes the printed court records on the microfilm, provides a comprehensive name and subject index to the case.

All the documents in the first eight volumes of this nine-volume set have been filmed with the following exceptions: long runs of patents by Edison and others that were entered into the record as exhibits; lengthy foreign-language documents (only the English translations have been filmed); lengthy extracts from the Edison Electric Light Company Bulletins (the bulletins appear in their entirety in the Company Records Series). The last volume in the set, which is entitled Argument on Appeal, April-May 1892, contains typewritten transcriptions of the arguments of Clarence A. Seward, Grosvenor P. Lowrey, and Richard N. Dyer for the plaintiff; and Samuel A. Duncan, Edmund Wetmore, and Frederic H. Betts for the defendant. This volume has not been filmed.

The volumes appear on the microfilm in the following order:

1. Digest of Proofs and Index [Vol. VIII]
2. Pleadings, complainant's prima facie proofs, decisions [Vol. I]
3. Defendant's proofs and depositions [Vol. II]
4. Defendant's proofs and depositions [Vol. III]
5. Defendant's depositions and exhibits [Vol. IV]
6. Complainant's Rebuttal - Depositions [Vol. V]
7. Complainant's Rebuttal - Exhibits [Vol. VI]
8. Supplemental Pleadings and Proofs [Vol. VII]

Edison Electric Light Co. v. United States Electric Lighting Co.

Digest of Proofs and Index (Volume VIII)

CIRCUIT COURT OF THE UNITED STATES,

SOUTHERN DISTRICT OF NEW YORK.

IN EQUITY—No. 3445.

THE EDISON ELECTRIC LIGHT COMPANY,
Complainant,

vs.

THE UNITED STATES ELECTRIC LIGHTING COMPANY,
Defendant.

ON LETTERS PATENT No. 223,898.

DIGEST

OF

COMPLAINANT'S PROOFS;

together with such of Defendant's Proofs as Complainant desires to refer to.

APPENDIX.

GENERAL INDEX TO RECORD.

Spec.

EATON & LEWIS,
Complainant's Solicitors.

CLARENCE A. SEWARD,
GROSVENOR LOWREY,
RICHARD N. DYER,
Of Counsel.

TABLE OF CONTENTS.

NOTE.

The numerals at the end of each digest refer, respectively, to the number of the volume of the record in this case, to the page and to the folio which marks the approximate place where the matter from which the digest has been made can be found. For example: The numerals at the end of the first digest on page 1, refer to Vol. IV., pp. 2738 to 2739, folios 10,951 to 10,954.

The testimony which is referred to in this digest as the "Interference Record" was taken between March, 1881, and April, 1883; that referred to as the "McKeesport suit," between May, 1888, and May, 1889; that referred to as the "Canadian suit," in November, 1888; while the testimony of Prof. Chas. F. Chandler and of Sir William Thomson, referred to as the "Trenton feeder suit," was taken between November 5, 1890, and March 9, 1891.

4087

APPENDIX.

ADAMS, Dr. Isaac.

ADAMS'S LAMP:

I had ample means after I sold my nickel patents in 1869. IV., 2720, **10880.**

This sketch shows how the lamp which I made in 1865 was constructed. (Affidavit of Sept. 27, 1890). IV., 2690.

The specimen lamp marked "Deft.'s Exh. Dr. Adams' Lamp No. 1," corresponds in part to Sketch No. 10.

In 1873 or 1874, this specimen lamp was used as an experiment at the shop of Smith, Phinney & Smith, to determine the effect of various gases on the incandescent carbons. This particular lamp fed a slip of carbon fastened to the two leading wires. The globe was filled with street gas, and after the current was turned on the globe became completely blackened on the inside, so as to practically obscure the light. At the same time I had a lamp similar to the one shown in Sketch No. 9, containing a vacuum, which was run by the magneto machine for certainly half an hour—possibly for an hour. The carbon slip in this lamp was made from arc light carbon dressed down to a sufficient degree of thinness. IV., 2698-9, **10791-5.**

I do not remember whether Alonzo C. Brackett was present when I tested my lamp. I recollect Henry A. Tweed, treasurer of the concern, was about the place at the time; also my brother, Aquila Adams. Have a faint recollection of carrying a lamp to the establishment of Julius Smith, on Sudbury street, Boston. As far as the early lamps were concerned—these made prior to 1869—my laboratory was closed to the public. As to the other places, there was no concealment necessary or intended. IV., 2700-1, **10797-802.**

The model now before me, marked "Model of Dr. Adams' Lamp of 1868," which has just been made under my general directions, represents, in a rough way, the lamp made by me in 1867 or 1868. This lamp requires an electro-motive force of fourteen volts, a current of eleven and one-half amperes and gives a light of forty candles. This corresponds to a resistance of one and two-tenth ohms. IV., 2710-1, **10840-3.**

None of the lamps which I made in 1867 to 1869 are in existence that I know of—nothing but the broken glass part of a lamp like those made at that time. This contains no mountings of the lamp—nothing but some ruby glass fused on both ends, from which circumstance I am able to recognize it. IV., 2715, **10858-9.** Also, 2743-4, **10971-3.**

ADAMS'S LAMP—(*Continued*):

As this glass part of my lamp exists to-day, it calls to my mind one of my experiments in securing a durable seal between a glass bulb and a large platinum conductor. To-day it shows no evidence of its use as part of an electric lamp. IV., 2746, **10082-3.**

I entirely ceased occupying myself with electric lamps in the spring or early summer of 1869. I made a lamp at a later period—the one tested at the New York Nickel Plating Company's works. It was, however, a mere illustration of the work which I had completed in 1869. It had some changes that I thought were improvements, but otherwise was like the early lamps. IV., 2720, **10878-80.**

As far back as 1879, I mentioned to Prof. Morton the fact that I had made a lamp covering the same elements as the Edison lamp. IV., 2722, **10886.**

BURNER OF CARBON:

The carbons used in the lamps which I made in 1865 and 1866 were made from gas-retort carbon, plumbago, leads from carpenters' pencils, and carbons made by the Bunsen process, which consisted in mixing lamp-black and powdered coke and molasses, which was compacted in a mould and baked. The product was then repeatedly dipped in a sugar solution and baked until the carbon was very tough (Affidavit of Sept. 27, 1890). IV., 2688-9, **10752-3.**

The carbon which I used in a vacuum lamp in 1873 or 1874 was made from arc light carbon dressed down to a sufficient degree of thinness. I ran it on the magneto machine for certainly half an hour—possibly for an hour. IV., 2699, **10794-5.**

In 1868 I prepared the carbon by filing or scraping it as thin as I could or dared to. I then soaked it in sugar and heated it in a crucible surrounded with fine carbonaceous powder. IV., 2712, **10846.**

The carbon made by me by the Bunsen process, as it came from the carbonizing furnace, was in cakes two or three inches long, two inches wide and about a quarter of an inch thick. This was worked into pieces varying from three-quarters of an inch to one and a half inches in length, and from one-eighth to one-quarter of an inch in width. They were from one-hundredth of an inch to half that in thickness. IV., 2719-20, **10875-8.**

The Bunsen process of making carbon, referred to in my affidavit, results, from the repeated dipping and heating, in a very dense and tough carbon. IV., 2702, **10808.**

CROSS-SECTION:

In 1865 and 1866 I made about a dozen lamps with carbon burners. These burners were approximately an inch to an inch and a quarter in length, about three-sixteenths of an inch in width, and from five to ten one-thousandths of an inch in thickness (Affidavit of Sept 27, 1890). IV., 2687, **10747-8.**

Note. The area of cross-section of these burners would be from .0009375 to .001875 of a square inch.

DURABILITY:

Witness states that, as to the statement in his affidavit that he thinks one of his lamps lasted some two hundred hours, it was guess-work; that he might just as well have said four hundred hours as two hundred hours; that he has no accurate idea as to how long in hours it did run; but that he knows it was run many times for a short period. IV., 2717, **10867-8.**

Witness states that, in saying in his direct examination that he had made "entirely durable" lamps, he considered that, if the lamp preserved its vacuum; if the carbon did not deteriorate sensibly to the eye, whether in use or not; if the lamp could be left to itself for several months at a time and then be tried again, that was a durable lamp. States that he did not use the expression with reference to continuous use, but to a continued existence, broken in upon by occasional lightings. IV., 2718-9, **10872-3.**

GEISSLER TUBES:

In 1862, 1863 and 1864, while pursuing my medical studies in Paris, I took great interest in chemistry and physics and devoted considerable time in acquiring a knowledge of the art of glass blowing, in which I became very expert, as also in the construction and exhaustion of Geissler tubes. Soon after my return to the United States, in 1864, I put my knowledge of the art of glass blowing to practical use in the manufacture of Geissler tubes, and in 1865 established a laboratory for work in chemistry and physics, and, for two or three years thereafter, as a matter of business, I made a large number of Geissler tubes. These I sold principally to E. S. Ritchie in Boston. I also sold some of them to Chester Bros., of New York, and others to Prof. Cooke, of Harvard University (Affidavit of September 27, 1890). IV., 2686, **10741-3.**

"The so-called Geissler tubes are apparatus made of glass for the purpose of showing the effect of high tension electricity in gases." IV., 2707, **10825.**

HEATING DURING EXHAUSTION:

I heated the carbon of my lamps during their exhaustion by passing a current through them, in order to expel occluded gases, just as was done with Geissler tubes, excepting that in the former case I used the battery direct, and in the latter case the spark from a Ruhmkorff coil. IV., 2710, **10838.**

INVENTION INVOLVED:

From 1867 to 1869, in making my carbon lamps, "I was interested in the fact as to whether or not the big platinum that I put in the glass would hold, because I have always considered—did then and do now—that I made an invention there which was a useful one. That was my interest in the lamp, and that is about all the interest I had in it." IV., 2716. **10862.**

LEADING WIRES:

The size of the platinum leading wires which I used in the carbon lamps made by me in 1865 and 1866 was about No. 16 Birmingham gauge (Affidavit of September 27, 1890). IV., 2688. **10749.**

Note—A wire of this size has a diameter of sixty-five thousandths of an inch. In modern sixteen candle-power lamps for multiple arc work the diameter of the leading wires varies approximately from twelve to sixteen thousandths of an inch, and the largest sizes used in Thomson-Houston series lamps are thirty-two thousandths of an inch in diameter.

RESISTANCE:

The lamp marked "Model of Dr. Adams' Lamp of 1868," which was made under my general direction and which, in a rough way, represents the lamp made by me in 1867 or 1868, has a resistance of one and two-tenths ohms. IV., 2711, **10843.**

SEALING:

All my earlier lamps were "more or less of a crude character. They were not the less practical on that account, however, and by that I mean, as to the perfection of the seal and the duration of the vacuum." After I got the proper material to make them of, I never knew one to leak. IV., 2703, **10810.**

Do not know how many lamps I made from 1867 to 1869, but I recollect that I broke a good many. There was a difficulty in their construction at that time, and that was the introduction into the glass of platinum wires of large cross-section. They would crack, and I had to overcome that difficulty. After I had once obtained the kind of glass I wanted, there was no difficulty in making the lamp. IV., 2714-5, **10855-7.**

From 1867 to 1869, in making my carbon lamps, "I was interested in the fact as to whether or not the big platinum that I put in the glass would hold, because I have always considered—did then, and do now—that I made an invention there which was a useful one. That was my interest in the lamp, and that was about all interest I had in it." I consider that at that time the introducing of platinum wires of relatively large cross-section was the novelty. In testing my lamps, from 1865 to 1867, I many times found the seal broken between the platinum wire and the glass. IV., 2716-7, **10862-5.**

SHAPING:

The carbons used in the lamps which I made in 1865 and 1866 were made in various ways. Sometimes I sawed and filed them into approximate shape from a piece of gas-retort carbon or cut them out from a block of plumbago. I also used the leads taken from carpenters' pencils. Having brought the carbons to their approximate shape, I glued them to a flat surface and ground down the exposed surface with a stone. Other carbons I produced by Bunsen's process, by mixing lampblack and powdered coke and molasses, which was compacted in a mold and baked. The product was then repeatedly dipped in a sugar solution and baked until the carbon was very tough (Affidavit of September 28, 1890). IV., 2688-9, **10752-3.**

In 1868, I prepared the carbon by filing or scraping it as thin as I could or dared to. I then soaked it in sugar and heated it in a crucible surrounded with fine carbonaceous powder. IV., 2712, **10846.**

From 1867 to 1869 I had some difficulty in the preparation of the carbon, although after a while that ceased to be a difficulty; that is, I mean in reducing them to a sufficient degree of thinness without fracture. IV., 2714, **10855.**

BARKER, Prof. George F.

AMPERE:

is the unit of electrical current. A pressure of one volt will cause a current of one ampere to flow through a conductor having one ohm resistance. I., 192, **767.**

ART, HISTORY OF:

shows that the term "carbon filament" was used for the first time in the art in the patent in suit. I., 67, **267.**

For more than forty years attempts to produce an incandescent lamp had been commercial failures, and up to date of patent in suit a successful incandescent lamp was unknown. I., 73, **292.**

BURNER:

of spiral form was old in the art, and the patent in suit is not limited to this form. I., 66, **262.**

of spiral form, closely coiled, is not necessary with a steady current, as then the light will not flicker. I., 72, **288.**

BURNER OF CARBON:

of Edison lamp is a new departure in the art. It has a small cross-section and small radiating surface, even when of considerable length, and is made of a material which results in a porous carbon of high specific resistance. The filamentary burner is first made of the required form and then carbonized, and is placed in an exhausted and sealed all-glass globe. I., 65, **257-8.**

in defendants' three (Zig-zag, M, and Tamadine) lamps is a filament made of the same kind of carbon as the filament of patent in suit, and it is made in the same way, *i. e.*, it is made of carbon produced by carbonization of a carbonizable material which has been reduced to the filamentary form prior to carbonization. I., 72, **286.**

of the old lamps was a rod of low resistance and of considerable cross-section and mass. I., 115, **459.**

of some of the old lamps were made from Carré carbons which were consolidated by subsequent treatment. Gas carbon, that deposited by nat-

BURNER OF CARBON—(*Continued*):

ural gas and anthracite, the three densest forms, have been also used. I., 126, **504.**

which would be serviceable, would be made by a skilled person at date of patent in suit upon directions contained therein to "carbonize" a cotton thread without further reference to a carbonizing process. I., 146, **582.**

which would be serviceable, could be made by a skilled person without difficulty by carbonizing a cotton thread by the ordinary process known at date of patent in suit. I., 148, **589.**

made from carbonized fibrous material had been used prior to 1878. I., 175, **698.**

were used in old lamps instead of platinum chiefly because of infusible nature of carbon. I., 194, **776.**

CANDLE-POWER:

Old lamps were of approximately one hundred candle-power. I., 115, **460.**

Burners of the old lamps, because of their considerable mass and cross-section, had to be raised to a high candle-power in order to bring them up to an incandescense at which their efficiency would be even ten watts per candle. I., 115, **459.**

CARBON:

of Edison's burner is porous and of high specific resistance, which is a new and important departure in the art. I., 65, **257.**

of high specific resistance reduces mass of filament by its porosity, and also the current required. In fact, so far as the current required is concerned, it makes the filament more filamentary. I., 70, **278.**

of high resistance, mentioned in first claim of patent in suit, refers to carbon of high specific resistance. I., 70, **277.**

produced by ordinary process of carbonization has a high specific resistance as compared with arc light carbon. I., 70, **277.**

of the filament, referred to in second claim of patent in suit, is not limited to any particular kind of carbon; neither is the way of making the filament limited to any particular method. I., 71, **281.**

of filament of defendant's three (Zigzag, M and Tamadine) lamps is same kind of carbon as that of filament of patent in suit, and the filament is

CARBON—(*Continued*):

made in the same way, *i. e.*, the carbon is produced by carbonization of a carbonizable material which has been reduced to the filamentary form prior to carbonization. I., 72, **286.**

is preferred as the material of burner, since its specific resistance is higher than that of any other suitable material. I., 81, **322.**

produced from a material in which the volatile parts are driven off during carbonization, leaving a porous residue, has a high specific resistance, and by its use the highest possible resistance is obtained. I., 105, **418.**

of filaments of patent in suit is made by process calculated to give it as high porosity and low density as possible consistent with durability, while carbon of the old lamps was made as dense as possible and consolidated by subsequent treatment. I., 125-6, **500-1.**

of burners of the old lamps were made by same process as are light carbons. Some of the old lamps used Carré carbons, which were consolidated by subsequent treatment. Gas carbon, that deposited by natural gas, and anthracite, the three densest forms, have been also used. I., 126, **504.**

produced by the process of patent in suit, *i. e.*, by carbonizing cotton and linen thread, wood splints, papers, carbon mixed with tar, etc., would have high specific resistance. I., 127, **506.**

of rods used in some of the old lamps, prior to date of patent in suit, and made by Carré, would be of same specific resistance as his arc light carbons made and used then. I., 133, **531.**

of filaments made from lamp-black and tar by process of patent in suit would have higher specific resistance than Carré carbons. I., 133, **532.**

Carré's process had for its object the production of a dense carbon, while patent in suit seeks to obtain a porous carbon. I., 134, **533.**

made by Gauduin's process might be made to have a specific resistance materially different from that of carbon made from lamp-black and tar by the process of patent in suit. Gauduin states that his second method, consisting in recarbonization after impregnation with tar, sugar, etc., results in production of "hard and compact carbon." I., 137, **547.**

made by Gauduin's process might have higher specific resistance than that made of lamp-black and tar by process of patent in suit, but Gauduin's patent indicates that it ought not to be. I., 139-40, **555-8.**

CARBON—(*Continued*):

Charcoal had been proposed for pencils for both incandescent and arc lighting prior to date of patent in suit. This charcoal would probably have substantially same specific resistance as the carbon of filament of first claim of said patent. I., 141, **564.**

made by carbonization of materials mentioned in patent in suit is necessarily of high specific resistance. I., 157, **625.**

made by carbonizing fibrous material had been used for burners of incandescent lamps prior to 1878. I., 175, **698.**

Sawyer's United States Patent No. 211,262 virtually states that progress aimed at prior to date of patent in suit was in using dense carbon of low specific resistance, but that the carbon used was not sufficiently homogeneous, hard and dense. The patent describes a way of accomplishing this result. V., 3424.

for arc lighting is plated with copper to reduce the resistance of the pencil and prevent too rapid combustion. Plating results in obtaining a low specific resistance of the pencil independently of the specific resistance of the carbon alone. V., 3429-30.

made by Carré and used for arc lighting prior to date of patent in suit were electro-plated, and since August, 1879, four-fifths of the carbons used have been plated. V., 3439.

CARBONIZATION:

Old processes, as well as that contemplated by patent in suit, involve the driving off of volatile parts by heat. I., 123, **489.**

The process spoken of in patent in suit as "carbonization" is not materially different from those known and practiced prior to its date. I., 124, **495.**

The process of carbonization for making carbon used in old lamps consisted in repeatedly immersing the carbon in a solution of carbonizable material, such as sugar syrup, and recarbonizing it, thus obtaining a dense and compact material. I., 125, **497.**

The directions in patent in suit to "carbonize" a cotton thread without other explanation of a carbonizing process would enable a skilled person at that time to produce a serviceable burner. I., 146, **582.**

In closed vessels, with the articles buried in sand or carbon dust, so as to exclude oxygen, was a customary process prior to date of patent in suit. Carré used carbon dust while carbonizing pencils for electric lighting. I., 147, **585-6.**

CARBONIZATION—(*Continued*):

A skilled person would, at date of patent in suit, have had no difficulty in carbonizing a cotton thread by the ordinary and well-known process, so as to produce a serviceable burner. I., 148, **589.**

CLAMPING:

in Edison lamp by means of a carbon paste insures an intimate contact between the carbon burner and platinum leading wires. I., 65, **259.**

by means of carbon paste is the subject of the fourth claim of patent in suit. I., 65, **259.**

of filamentary carbon burner to the leading wires can be effectively maintained, which was not the case with burners used in prior lamps. I., 68, **272.**

if ineffective, results in overheating and an arc action at the clamps, which destroys the burner. I., 69, **273.**

of a filament by means of metallic clamps or carbon paste is effective. I., 73, **289.**

CLAMPS:

do not get overheated with a carbon filament, and danger to the contact between the burner and leading wires is prevented. This advantage is due to small cross-section of filament and is independent of its length. I., 69, **274.**

Metallic clamps were old at date of patent in suit. I., 73, **289.**

COMMERCIAL SUCCESS:

Old incandescent lamps were not a. I., 63, **252.**

had not attended the efforts which for forty years had been made to produce an incandescent lamp, and up to date of patent in suit a successful lamp was unknown. I., 73, **292.**

While no successful incandescent lamp was in use prior to date of patent in suit, lamps made in accordance with Edison's invention came into extensive use and in enormous numbers immediately thereafter, and all lamps now in use are so made. I., 74, **296.**

CROSS-SECTION:

of Edison's carbon burner is small and a new departure of importance in the art. I., 65, **257.**

That the resistance of a conductor would be increased by diminishing its cross-section was known prior to 1875. I., 101, **404.**

CROSS-SECTION—(*Continued*):

of burner of series lamp should be diminished and its length increased to convert it into a multiple arc lamp. I., 106, **424.**

of carbon rod burners of old lamps, and also their mass, was considerable. I., 115, **459.**

of rod burners of the old lamps is relatively larger than that of the filamentary burner of patent in suit. I., 119, **475.**

of rod burners of some of old lamps was fifty times that of the filament described in patent in suit. I., 120, **477.**

of a burner must be small or thread-like to be the filament of patent in suit. I., 121. **483.**

Shaping the material into filamentary form before its carbonization is done only for purpose of obtaining small cross-sections to burner. I., 159. **633.**

of filament of patent in suit is not necessarily of circular or any particular form. I., 166, **663.**

If area of cross-section of filament of patent in suit remains unchanged, it is still a filament, no matter what the form of its cross-section. I., 168. **669.**

If cross-section of a carbon burner were so large that the advantages set forth in patent in suit as secured by filamentary burner could not be obtained, it would not be the filament of said patent. I., 168, **672.**

CURRENT:

required by a carbon filament is moderate, permitting the use of small platinum leading wires which can be readily sealed into the glass walls of lamp chamber. This advantage is due to small cross-section, and is independent of length of filament. I., 68, **269-70.**

That a current divides itself among branch (multiple arc) circuits in inverse ratio to their resistances was known to me, as a deduction from Kirchoff's law, prior to 1875. I., 96, **382.**

Old lamps required a current of twenty-four amperes as a minimum, while defendants' lamps require from 0.55 to 1.1 amperes, and the ordinary Edison lamps from 0.45 to 0.5 ampere. These are comparatively moderate currents as compared with that required by old lamps. I., 115, **457-8.**

CURRENT—(*Continued*):

required to raise the filamentary burner of patent in suit to an economical incandescence is what I mean by a "moderate current." It is moderate as compared with the current required by the old lamps. I., 117, **465.**

Does not think a current of ten amperes would be a "moderate" current. Does not know of a modern incandescent lamp being commercially in use which requires a current of ten amperes. I., 117, **467.**

Thinks a current of two amperes might be a "moderate" current. I., 117, **468.**

DISCOVERY:

Schwendler, in 1879, said that lighting by incandescence could not become practical, unless a better material than platinum were discovered, out of which to make the burner. It should have a higher melting point, a lower specific weight and heat, and must not combine with oxygen at high temperature. I., 89, **356.**

DURABILITY:

Vacuum is essential to the durability of a carbon burner. I., 71, **282.**

DYNAMOS:

"I know all other generators, and Edison's is best of all. With a resistance of only one ohm he gets 164 units of energy. The theory upon which it is built is exactly the reverse of previous inventors of electrical generators. Edison aims at a low resistance, but high electro-motive force" (Lecture of March 24, 1880). VI., 4227.

Edison's machine is undoubtedly one of the most efficient now made (Profs. Rowland and Barker "On the Efficiency of Edison's Electric Light," March 27, 1880). VI. 4235.

ECONOMY:

Vacuum is essential to economy of a lamp because the current required with a vacuum has to be increased many times to obtain the same amount of light, if the chamber is filled with a gas at atmospheric pressure. I., 71, **283.**

Edison's invention has given us an electric light of practically the same economy as gas. I., 74, **295.**

in working electrical apparatuses in general, when arranged in multiple arc, is to be obtained by making them of high resistance. This follows from well-established electrical laws. I., 81, **323.**

in working telegraphic sounders in multiple arc would be improved by making them of high resistance. I., 83, **330.**

ECONOMY—(*Continued*):

in working gas lighters in multiple arc would be increased by making them of high resistance. I., 84, **333.**

of gas lighters, telegraph instruments, etc., as far as dependent on their resistance as compared with that of the conducting wires, is comparatively unimportant and practically is not considered. Other factors, such as construction and the like, are of more significance. I., 86-7, **344-5.**

EFFICIENCY:

Profs. Rowland and Barker, in their tests, obtained from 109 to 209 candles of light per horse-power from Edison's lamps, which were run at a candle-power varying from 9.2 candles to 33.5 candles each (Paper "On the Efficiency of Edison's Light," March 27, 1880). VI., 4235.

of old lamps was low, about ten watts per candle as a minimum. I., 114, **456.**

Burners of the old lamps, because of their considerable cross-section and mass, had to be raised to high candle-power in order to bring them up to an incandescence at which their efficiency would be even ten watts per candle. I., 115, **459.**

ELASTICITY AND FLEXIBILITY:

are characteristics of a filamentary carbon burner, by virtue of which it can be attached to rigid leading wires or supports without danger of rupture by shocks and expansion. I., 69, **276.**

of burner proceed from shaping the material into filamentary form and its subsequent carbonization. I., 164, **654.**

Flexibility increases with length of filament, but elasticity is not altered. I., 164, **654.**

ENERGY:

That the energy developed in different parts of an electric circuit by a current is proportional to the relative resistances of the respective parts of the circuit was known to me prior to 1875 as a deduction from Joule's law. I., 96, **383.**

FILAMENT:

means, primarily, a thread-like body, and the term "carbon filament" involves a carbon burner of small or thread-like cross-section. I., 67, **267.**

is defined by Webster as "a thread or thread-like object or appendage; a fiber." The term had not acquired a technical meaning at date of patent

FILAMENT—(*Continued*):

in suit, and was used therein in the ordinary sense and for the first time in the history of the art. I., 107, **427.**

The significance of the term, as applied to the burner of an incandescent lamp, lies solely in the small or thread-like nature of its cross-section. I., 108, **432.**

The term does not involve the idea of length or resistance. I., 109, **435.**

A burner small enough in cross-section to obtain the advantages specified in the patent in suit as following from the use of the burner of small cross-section therein described, would be small or thread-like and a filament. I., 113, **452.**

FILAMENT OF CARBON:

Term "carbon filament" first used in history of the art in the patent in suit. I., 67, **267.**

involves the idea of a carbon burner of small or thread-like cross-section. I., 67, **267.**

requires only a moderate current, hence small leading wires of platinum which can be readily sealed into the glass walls of the lamp chamber. This advantage is due to the small cross-section, and is independent of the length of the filament. I., 68, **269-70.**

has a small radiating surface, also a high resistance and small mass per unit of radiating surface, which conditions permit of practical and economical subdivision, because only a moderate current is required to raise the burner to an economically high temperature, and also because the small radiating surface will give about the light of an ordinary gas jet. I., 68, **271.**

makes it possible to maintain an effective contact at the clamps between the burner and leading wires, in which respect prior lamps failed. I., 68, **272.**

does not give up much heat to the clamps and leading wires, hence saving energy and preventing danger of injury to the clamps and points where the leading wires are fused into the glass. This advantage results from the small cross-section of the filament and is independent of its length. I., 69, **274.**

if increased in length gives a high total resistance and enables the lamp to be used in multiple arc. I., 69, **275.**

did not remove existing difficulties in the way of constructing a lamp because of its length, but because of its small cross-section. I., 69, **275.**

FILAMENT OF CARBON—(*Continued*):

is elastic and flexible; hence it can be attached to rigid leading wires or supports without danger of being ruptured by shocks or expansion. I. 69, **276.**

of first claim of patent in suit is a carbon burner of any length and of a cross-section sufficiently small to produce the following important results: First, the use of platinum leading wires small enough to be readily fused into the glass walls of the lamp chamber, which will carry the moderate current required without heating so as to crack the glass; second, the small radiating surface, and high resistance and small mass per unit of radiating surface which make it possible to subdivide the light and to economically obtain a small light with a moderate current; third, an effective contact between the burner and leading wires which will be permanent with the moderate current required; fourth, freedom from conduction of large amount of heat back from the burner to clamps and leading wires, resulting in a saving of energy and prevention of injury to clamps and sealing. I., 69, **276.**

of Edison's lamps, referred to in first claim of patent in suit, is made by first giving the material the filamentary form, when it can be easily manipulated, and then carbonizing it. This is the only practical way of making a filament. I., 70, **279.**

"Carbon filaments" in second claim of patent in suit should be "carbon filament." I., 71, **281.**

of Edison's lamp, referred to in second claim of patent in suit, is not limited to any particular kind of carbon or to any particular way of making the filament. I., 71, **281.**

is the burner of defendants' three (Zig-zag, M. Tamadine) lamps. It is made of the same kind of carbon as filament of patent in suit and in the same way, *i. e.*, of carbon produced by carbonization of a carbonizable material which has been reduced to the filamentary form prior to carbonization. I., 72, **286.**

of first claim of patent in suit calls for a burner of small cross-section (irrespective of its length), made of carbon of high specific resistance, which has been produced by the carbonization of a material after its reduction to the filamentary form. I., 109-10, **436-7.**

of second claim of patent in suit calls for a burner of small cross-section (irrespective of its length), made of any kind of carbon and in any way. I., 109-110, **436-7.**

of first and second claims of patent in suit must be small enough in cross-section to make it possible to use a moderate current, hence small platinum leading wires; to obtain a small radiating surface, and small mass,

FILAMENT OF CARBON—(*Continued*):

, hence a high resistance per unit of radiating surface; also to get elasticity and flexibility, and to have a small amount of heat conducted back to the leading wires and an effective contact between them and the carbon burner. I., 111, **441.**

of patent in suit is made by process calculated to produce carbon of as high porosity and low density as is consistent with durability, while carbons of the old lamps were made as dense as possible, and were consolidated and made still less porous by subsequent treatment. I., 125-6, **500-1.**

Lamp with filament of carbon having a specific resistance not higher than that of carbons of the old lamps would be the lamp covered by first two claims of patent in suit if filament were in the exhausted all-glass chamber. I., 128, **511.**

having specific resistance not higher than that of some carbons used for arc lighting would be within first claim of patent in suit. I., 129, **513.**

made by process described in patent in suit, even if its specific resistance were as low as that of some arc light carbons, would attain the advantages set forth in said patent, although to a lower degree, corresponding to the lowness of specific resistance. I., 129, **515.**

of first claim of patent in suit need not have higher specific resistance than carbons of the old lamps. I., 130, **520.**

of as low specific resistance as that of the best examples of arc light carbons (those having greatest density and lowest specific resistance practically attainable) would not be without first claim of patent in suit. I., 131, **524.**

of first claim of patent in suit should have a higher specific resistance than that of some arc light carbons previously in use. I., 132, **528.**

which would be a practical burner could be made by a skilled person from cotton thread, or from lampblack and tar filaments, by the ordinary method of carbonization known at date of patent in suit, in view of the directions contained therein concerning "a cotton thread properly carbonized" and tar-putty filaments to be "carbonized in a closed chamber by subjecting it to a high heat." I., 148, **591.**

is easily made from the materials mentioned in patent in suit, and the carbonization of this material necessarily results in production of carbon of high specific resistance. I., 156-7, **624-5.**

"Filament of carbon of high resistance," taken as a whole, is referred to by the words "made as described" in first claim of patent in suit. I., 157, **626.**

FILAMENT OF CARBON—(*Continued*):

of second claim of patent in suit must be of small cross-section, and does not depend upon length, or such a length as will make its total resistance high enough to adapt it to multiple arc work. I., 160-1, **640-1.**

of patent in suit is not necessarily of circular or any particular form of cross-section. I., 166, **663.**

and "carbon wire" are synonymous terms as used in patent in suit. I., 167, **666-7.**

of patent in suit would be a filament, no matter what the form of cross-section, provided the area of cross-section remains unchanged. I., 168, **669.**

If cross-section of a carbon burner were so large that the advantages set forth in patent in suit, as secured by filamentary burner, could not be obtained, it would not be the filament of carbon of said patent. I., 168, **672.**

Arrangement of filament in any form, coiled, straight or otherwise, was open to Edison at date of patent in suit. I., 173, **692.**

substituted for the platinum wire burner in Edison's lamp described in United States Patent No. 227,229 would embody the invention covered by first claim of said patent and would be the lamp of the patent in suit. I., 183, **730-1.**

FIRST CLAIM OF PATENT IN SUIT:

obviously includes a suitable lamp chamber. I., 67, **265.**

That lamp globe be exhausted is a necessary part of invention covered by first claim. I., 155, **617.**

Lamp chamber, which is a necessary element of first claim, is substantially the "receiver made entirely of glass" spoken of in second claim. It is the only chamber practically useful. I., 155, **618.**

Metallic wires spoken of in first claim must "pass through the glass" of the globe which is an element of that claim. I., 155, **619.**

FOURTH CLAIM OF PATENT IN SUIT:

is for a method of securing the carbon filament to the platinum leading wires by carbon paste. I., 65, **259.**

GAS LIGHTERS:

were used in multiple arc prior to 1879. They formed closed circuits while in operation, although this was only for an instant. I., 83, **331-2.**

GAS LIGHTERS—(*Continued*):

described in Gardiner's United States Patent of 1872 are arranged in multiple arc. There is no evidence to show that they are of high resistance. I., 85, **337.**

In 1872 I would have made platinum wire gas-lighters of high resistance as compared with the resistance of conducting wires, whether they were to be used on single circuits or in multiple arc. I., 85, **339.**

Platinum coils of gas-lighters could not be economically or practically substituted for the filamentary carbons of defendants' lamps described and claimed in patent in suit. I., 193, **771.**

JOULE'S LAW:

Incandescent lamps in multiple arc are amenable to Joule's law. I., 101, **401.**

LAMP, ARC:

concerning the Thomson-Houston vibrating arc lamp, "* * * the principle involved seems to me sufficiently absurd, involving as it does a denial of the fundamental doctrine of the conservation of energy" (Letter to Prof. Morton, of October 21, 1878). IV., 2099.

Principle upon which it works explained. I., 63, **249.**

LAMP CHAMBER:

of Edison's lamp is made entirely of glass, closed by fusion of the glass, and capable of maintaining a vacuum, as distinguished from the lamp chambers of old lamps, which were made of separable parts with cemented joints. This is a new and important departure in the art. I., 65, **258.**

which is suitable for the purpose, is obviously included in first claim of patent in suit. The chamber described in the patent is the only practically useful one. I., 67, **265-6.**

"Receiver" of second claim of patent in suit is made of one entire piece of glass, with joints closed by fusion of the glass, and is exhausted. I., 71, **282.**

of Edison's lamp will maintain a vacuum. I., 71, **282.**

of old lamps would not maintain a vacuum, being jointed. I., 71, **282.**

of defendants' three (Zig-Zag, M and Tamadine) lamps is the same as that of patent in suit, because it is made of an entire piece of glass, closed by fusion of the glass, and is exhausted of air. The platinum leading wires are sealed into the glass by fusion, as in the patent in suit. I., 72, **287.**

LAMP CHAMBER—(*Continued*):

which is necessary element of first claim is substantially the "receiver made entirely of glass," spoken of in second claim. It is the only chamber practically useful. I., 155, **618.**

of old lamps were made with separate parts, which could not be united by fusion, and no attempt was made to seal in the leading wires in same manner. I., 177, **707.**

LAMP, INCANDESCENT:

Principle upon which it works explained. I., 62, **248.**

Difference between it and the arc and semi-incandescent lamps explained I., 63, **250.**

Old incandescent lamps were not commercially successful. I., 63, **252.**

New departure in art of making them, as described in patent in suit, embodies several important features, which are enumerated. I., 65, **257-8.**

Defendants' three (Zigzag, M and Tamadine) lamps have all the elements named in the first and second claims of the patent in suit combined and operating in the same way and for the same purpose. I., 72, **285.**

invented by Edison was the creation of a new art in lighting by electricity. For more than forty years attempts to produce an incandescent lamp had been commercial failures, and up to date of patent in suit a successful incandescent lamp was unknown. It was at once conceded that Edison had produced an economical, durable and simple lamp, and had solved the problem of subdivision, and capital at once embarked in the manufacture and installation of plants for lighting cities by electricity instead of gas, which Edison's lamp made possible, and central stations for lighting were rapidly installed. No single invention in electric lighting has done more to revolutionize methods of household illumination. Edison's lamp, unlike gas, prevents corruption of the air and gives light of practically equal economy. It is unaccompanied by the heat which burning of gas produces, and the resulting deleterious effects are absent. While no successful lamp was in use prior to date of patent in suit, lamps made in accordance with Edison's invention came into extensive use and in enormous numbers immediately thereafter, and all lamps now in use are so made. I., 73-4, **291-6.**

To-day I would make multiple arc lamps of higher resistance than series lamps, in fact, of as high resistance as possible; first, by selecting material of high specific resistance; second, by selecting it in the form in which it possesses the highest specific resistance; third, by reducing its cross-sections as far as practicable; fourth, by increasing its length to get required radiating surface and illuminating power. I., 104, **415-16.**

LAMP, INCANDESCENT—(*Continued*):

To convert a series lamp into a multiple arc lamp of same candle-power requires that the cross-section of the series burner be diminished and its length increased. I., 106, **424.**

Efficiency of old lamps was low, about ten watts per candle as a minimum. I., 114, **456.**

Old lamps had an illuminating power of approximately one hundred candles. I., 115, **460.**

Old lamps required a current of twenty-four amperes as a minimum. Compared with this, the current required by defendants' and Edison lamps (from 0.45 to 1.1 ampere) is moderate. I., 115, **457-8.**

LAMP, SEMI-INCANDESCENT:

Principle upon which it works explained. I., 63, **249.**

LEADING WIRES:

required with a carbon filament are small and hence can be readily sealed into glass walls of lamp chamber. This advantage is due wholly to the small cross-section of the filament, which requires only a moderate current. I., 68, **269-70.**

with a filament do not conduct back heat to the places where they are sealed into the glass chamber, and danger of fracture is prevented. This advantage is due to small cross-section of filament and is independent of its length. I., 69, **274.**

which are referred to in second claim of patent in suit as "conductors passing through the glass" are the platinum wires which are to be sealed into the glass walls of lamp chamber by fusion of the glass upon them. They serve to carry the current to and lead it from the carbon filament. I., 71, **284.**

of defendants' three (Zig-zag, M and Tamadine) lamps are of platinum, and are sealed into the glass walls of lamp chamber by fusion of the glass upon them, as in patent in suit. I., 72, **287.**

Metallic wires spoken of in first claim of patent in suit must "pass through the glass" of the globe, which is an element of that claim. I., 155, **619.**

It was known prior to 1878 that platinum wires made the best conductors for conveying a current through walls of an exhausted glass chamber, and that an effectual way to make tight joint around the wires was by fusion of the glass upon them. I., 174, **696.**

of old lamps were not sealed into wall of lamp chamber by fusion of the glass. I., 177, **707.**

LENGTH:

of a carbon filament, if increased, gives high total resistance and enables lamp to be used in multiple arc. I., 69, **275.**

of the filamentary burner did not remove existing difficulties in constructing a lamp. This was due to its small cross-section. I., 69, **275.**

That resistance of a conductor would be increased by increasing its length was known prior to 1875. I., 101, **404.**

of burner of series lamp should be increased and its cross-section diminished to convert it into a multiple arc lamp. I., 106, **424.**

of the burner has nothing to do with "carbon filament" of second claim of patent in suit. I., 110, **439.**

is not an element of the carbon filament of second claim of patent in suit, nor such a length as will make its total resistance high enough to adapt it to multiple arc work. I., 160-1, **640-1.**

LIGHT:

will not flicker when the current is steady, making it unnecessary to use closely coiled spiral burner. I., 72, **288.**

MASS:

of a filamentary carbon burner is small, and its resistance is high per unit of radiating surface, with attendant advantages (see, Filament of Carbon has a small radiating surface, etc.). I., 68, **271.**

of the carbon rod burners of the old lamps and also their cross-section was considerable. I., 115, **459.**

MICROHM:

is the one-millionth of an ohm. V., 3424.

MULTIPLE ARC:

Increase in length of filament, give a high total resistance and enables it to be used in multiple arc. I., 69, **275.**

Gas lighters were used in multiple arc prior to 1879. They formed closed circuits, while in operation, although this was only for an instant. I., 83. **331-2.**

Gardiner's United States Patent of 1872 describes electrical apparatuses for gas lighting, etc., operated in multiple arc. There is no evidence to show that they are of high resistance. I., 85, **337.**

MULTIPLE ARC—(*Continued*):

Telegraphic sounders were arranged used in multiple arc prior to 1879, according to a work on the electric telegraph written by Pope and published in 1874. The book does not bear evidence that they were of high resistance. I., 87, **348.**

Khotinsky's French Patent of 1875 provides for a multiple arc arrangement of incandescent lamps. I., 89, **353.**

Woodward's United States Patent of 1876 provides for a multiple arc arrangement of incandescent lamps. I., 89, **353.**

No reference to use of high resistance lamps in multiple arc prior to 1878 is to be found. I., 91, **361.**

Incandescent lamps in multiple arc are amenable to Joule's law. I., 101, **401.**

arrangement of lamps means that they are placed across two leading conductors like rungs of a ladder between its sides. They form *simultaneous* paths for the current. "Multiple arc" is synonymous with "in parallel." I., 191, **764.**

OHM:

is the unit of electrical resistance. A copper wire one-thousandth of an inch in diameter and one foot long has a resistance of one ohm. I., 192, **766.**

PATENT IN SUIT:

is not limited to a burner of spiral form. This and other forms were old. I., 66, **262.**

contemplates any suitable shape of filamentary burner. Close coiling of the filament into the spiral form is unnecessary with a steady current, since there will be no appreciable flickering of the light. I., 72, **288.**

RADIATING SURFACE:

of a carbon filament is small, while its resistance is high and its mass is small per unit of radiating surface, resulting in advantages (see, Filament of Carbon has a small radiating surface, etc.). I., 68, **271.**

mentioned in third paragraph of patent in suit as the "slight surface from which radiation can take place," refers to the exterior surface of a coiled (spiral) burner, which is only a small part of its entire surface. I., 181, **722.**

"Unit of radiating surface" defined. I., 191, **762.**

of Edison's carbon burner is small, even when of considerable length, and is a new and important departure in the art. I., 65, **257.**

RESISTANCE:

of a filamentary carbon burner is high and mass is small per unit of radiating surface, with attendant advantages (see, Filament of Carbon has a small radiating surface, etc.) I., 68, **271.**

total, of a filament may be made high, if its length be increased, which enables it to be used in multiple arc. I., 68, **275.**

high, mentioned in first claim of patent in suit, refers to high specific resistance. I., 70, **277.**

Lane-Fox first mentioned the importance of having the burner of high resistance, in a patent dated October, 1878, and prior to date of patent in suit. He knew of it as an unattainable desideratum. (Patent referred to is British Patent No. 3998, of 1878; see page 18[illegible] 240 x-Q). I., 77, **307-8.**

The bare fact of importance of a burner having high resistance was not first disclosed in patent in suit. I., 77, **308.**

Edison stated the importance of the principle of high resistance in using lamps in multiple arc in his British Patent of 1879, and was aware of it in 1878. He, like Lane Fox, unsuccessfully sought to obtain the desired high resistance with a platinum burner, which cannot be done. (Patent referred to is British Patent No. 2402, of June 17, 1879; see page 184, 241 x-Q.) I., 78, **309-11.**

To make the burner of high enough resistance to obtain economical subdivision in multiple arc, as Edison attempted to do in 1878 in his platinum lamp, is the theoretically correct principle, whether the burner be made of platinum or carbon. I., 80-1, **319-21.**

of electrical apparatuses in general, if to be economically worked in multiple arc, should be high. This follows from well established electrical laws I., 81, **323.**

That electrical apparatuses in general, if worked in multiple arc, should have a high resistance, in order, practically, to subdivide the current among them, was not well known long prior to date of patent in suit. I., 82, **327.**

of telegraphic sounders is low. If worked in multiple arc, the economy of working would be improved by making them of high resistance. I., 83, **330.**

If gas lighters were made of high resistance, the economy of working would be increased. I., 84, **333.**

Electrical apparatuses for gas lighting, etc., described in Gardiner's United States Patent of 1872, are arranged in multiple arc. There is no evidence to show that they are of high resistance. I., 85, **337.**

RESISTANCE—(*Continued*):

In 1872 I would have made platinum wire gas-lighters of high resistance, as compared with the resistance of the conducting wires, whether they were to be used on single circuits or in multiple arc. I., 85, **339.**

of gas lighters, telegraph instruments, etc., as compared with that of the conducting wires in relation to the economy of operation, is comparatively unimportant, and practically is not considered. Other factors, such as construction and the like, are of more significance. I., 86-7, **344-5.**

six times greater than another is not necessarily high as compared with that other. I., 88, **351.**

of Khotinsky's lamp of 1875, and Woodward's lamp of 1876, both intended for use in multiple arc, was low (not over one or two ohms). Hence principle of high resistance for lamps in multiple arc, to accomplish subdivision, appears not to have been common knowledge at that time. Moreover, Schwendler, in 1879, said subdivision must necessarily be a failure, and that lighting by incandescence could not become practical, unless a better material than platinum were discovered, out of which to make the burner. I., 89, **354-6.**

In 1875 and 1876 I would not have made Khotinsky and Woodward lamps of high resistance. I., 90, **357.**

is not the only question affecting subdivision. It is a function of other conditions as well. I., 91, **361.**

No reference to use of high resistance lamps in multiple arc prior to 1878 is to be found. I., 91, **361.**

In 1879, Preece said that the exact relations between current, heat, temperature, mass and light are unknown, and that extensive subdivision is impossible. From this and the state of the art at date of Khotinsky and Woodward patents, it appears that the advantage of high resistance in lamps used in multiple arc was not appreciated. I., 91-2, **362-5.**

In 1875 and 1876 I would not have made resistance of Khotinsky and Woodward lamps as high as practicable, consistent with the nature of the material proposed for the burners and the methods of manipulating such materials, which were then known. I., 92, **365.**

That a current divides itself among branch (multiple arc) circuits in inverse ratio to their resistances was known to me prior to 1875, as a deduction from Kirchhoff's law. I., 96, **382.**

That the energy developed in different parts of an electric circuit by a current is proportional to the relative resistances of the respective parts of the circuit, was known to me prior to 1875, as a deduction from Joule's law. I., 96, **383.**

RESISTANCE—(*Continued*):

With knowledge of Kirchhoff's and Joule's laws, and to secure economy, I would not, in 1875-6, have attempted to make lamps for use in multiple arc, as set forth by Khotinsky and Woodward, of a resistance relatively high compared with that of the rest of the circuit, *i. e.*, the generator and conducting wires. I., 98-9, **392-4** and **396.**

Knowledge of the art in 1875-6 was not sufficient to enable the advantages of high resistance to be understood and appreciated, so as to become a factor in the construction of incandescent lamps. I., 100, **399.**

That resistance of a conductor would be increased by diminishing its cross-section or increasing its length, was known prior to 1875. I., 101, **404.**

In 1875, I would have varied the total resistance of a conductor by varying its length or cross-section, or by altering the specific resistance of the material, the nature of the material remaining the same. I., 102, **405.**

To-day I would make multiple arc lamps of higher resistance than series lamps, in fact, of as high resistance as possible; first, by selecting material of high specific resistance; second, by selecting it in the form in which it possesses the highest specific resistance; third, by reducing its cross-section as far as possible; fourth, by increasing its length to get required radiating surface and illuminating power. I., 104, **415-16.**

of the carbon rod burners of old lamps was low, and they had considerable cross-section and mass. I., 115, **459.**

A lamp of four ohms resistance, being that of the old lamps, as stated in patent in suit, would be within claims of said patent, if the burner were a filament placed in an exhausted all glass globe with leading wires passing through the glass; and further, if the filament were made of carbon of high specific resistance, produced from material which had been reduced to the filamentary form before carbonization. I., 118, **470.**

Lamps of four ohms resistance having filamentary burners of carbon of high specific resistance could be operated in multiple arc without requiring large conductors, because the current required is independent of length of filament. The rods of the old lamps would require large conductors, because their relatively large cross-section and the low specific resistance of their carbon call for a large current. I., 118-119, **472-3.**

The patent in suit, in stating that attempts of previous persons had been to reduce the "resistance of the carbon rods," refers to total resistance. I., 144, **576.**

RESISTANCE—(*Continued*):

Total resistance of burner in lamp of first two claims of patent in suit may be high or low, to adapt it to multiple arc or series work, and be indefinitely varied. I., 161-2, **644-6.**

The term "high resistance," used in patent in suit, where it states that object of invention is to produce a lamp of high resistance, so as to allow of subdivision, refers to that kind of resistance which allows of subdivision and which is expressed in terms of its ratio to the radiating surface. I., 179-80, **713-18.**

RESISTANCE, SPECIFIC:

Edison's burner is made of porous carbon of high specific resistance, which is a new and important departure in the art. I., 65, **257.**

Carbon of high specific resistance reduces mass of filament by its porosity, and also the current required. In fact, as far as the current required is concerned, it makes the filament more filamentary. I., 70, **278.**

of carbon filament of Edison's lamp, referred to in first claim of patent in suit, is high. I., 70, **277.**

of carbon is higher than that of any other material suitable for a burner; hence it is preferable over others. I., 81, **322.**

To-day I would select a material for the burner which would have a high specific resistance, and in the form in which it would have the highest specific resistance. This material would be carbon produced by carbonization of material of which the volatile parts would be driven off during carbonization, leaving a porous carbon residue of high specific resistance. I., 104-5, **416-18.**

has nothing to do with the carbon of "carbon filament" of second claim of patent in suit. I., 110, **439.**

of the carbon of rod burners of the old lamps is lower than that of the carbon of filament of patent in suit. I., 119, **475.**

of carbon of burner described in patent in suit would be high, as it is made in a way calculated to make it porous; while specific resistance of carbon of burners of the old lamps would be low, since it is made by a process calculated to make it dense and compact. I., 122, **486.**

The reference in patent in suit to the advantage of using a carbon wire of "high resistance" is to high specific resistance. I., 127, **507.**

Carbon of high specific resistance would be produced by process of patent in suit, *i. e.*, carbonizing cotton and linen thread, wood splints, papers, carbon mixed with tar, etc. I., 127, **506.**

RESISTANCE, SPECIFIC—(*Continued*):

Lamp with filament of carbon of specific resistance not higher than that of carbons of old lamps would be the lamp of first two claims of patent in suit, if filament were in the exhausted, all-glass chamber. I., 128, **511.**

Filament of carbon having specific resistance not higher than that of some carbons used for arc lighting would be within first claim of patent in suit. I., 129, **513.**

Filament of carbon made by process described in patent in suit, even if its specific resistance were as low as that of some arc light carbons, would attain the advantages set forth in said patents, although to a lower degree, corresponding to the lowness of the specific resistance. I., 129, **515.**

of filament of first claim of patent in suit need not be higher than that of carbons of the old lamps. I., 130, **520.**

Filament of carbon of as low specific resistance as that of the best examples of arc light carbons (those having greatest density and lowest specific resistance practically attainable) would not be within first claim of patent in suit. I., 131, **524.**

of carbon of filament of first claim of patent in suit should be higher than that of some arc light carbons previously in use. I., 132, **528.**

of carbon rods used in some of the old lamps prior to date of patent in suit, and made by Carré, would be the same as that of his arc light carbons made and used then. I., 133, **531.**

of carbon of filament made by process of patent in suit would be higher than that of Carré carbons. I., 133, **532.**

of carbon made by Gauduin's process might be made materially different from that of carbon made from lampblack and tar made by process of patent in suit. Gauduin states that his second method, consisting in recarbonization after impregnation with tar, sugar, etc., results in production of "hard and compact carbon." I., 137, **547.**

of Gauduin's carbon might be higher than that of carbon made from lampblack and tar by process of patent in suit, but Gauduin's patent indicates that it ought not to be. I., 139-40, **555-8.**

Pencils of charcoal had been proposed for both incandescent and arc lighting prior to date of patent in suit. This charcoal would probably have substantially same specific resistance as the carbon of filament of first claim of said patent. I., 141, **564.**

of carbon is its resistance as a substance independently or any dimensions which the carbon may have. It is expressed in terms of the resistance

RESISTANCE, SPECIFIC—(*Continued*):

in ohms of a cube of the carbon measuring one centimetre on a side. I., 142, **566.**

of carbon made by carbonizing the materials mentioned in patent in suit is necessarily high. These materials are easily given filamentary form. I., 156-7, **624-5.**

High specific resistance of the carbon of filament of first claim does not depend upon the fact that the material was given the filamentary form before carbonization. I., 158, **632.**

of carbon may vary from two hundred to seven hundred times that of platinum. I., 192, **768.**

of carbon of defendant's filaments varies from 3,800 to over 6,300 microhms, while that of carbon used in electric lighting before date of patent in suit was as low as 600 microhms, that of the former being at least from six to ten times that of the latter. V., 3422.

of gas carbon used in Lodyguine's old incandescent lamp was about 2,250 microhms as given by Wilde. Old arc light carbons, according to Farmer, had specific resistance of 2,400 to 2,956 microhms. Fontaine used gas carbon in Konn's old incandescent lamp, which he says had specific resistance of 572 microhms. The core of Sawyer's incandescent carbon (understood to be Carré carbon) had 3,700 microhms, the carbon of the burner as a whole 1,050 to 1,360 microhms, and the portion deposited by Sawyer's process (producing a dense carbon) 826 microhms specific resistance. The forty-one electric light carbons measured by Dr. Morton varied in specific resistance from 3,252 to 3,694 microhms, which is lower than that of the carbon in any of defendants' lamps, and little more than half that of the highest. V., 3422-24.

Sawyer's United States Patent No. 211,262, virtually states that progress aimed at before date of patent in suit was in using dense carbon of low specific resistance, but that the carbon used was not sufficiently homogeneous, hard and dense. The patent describes a way to accomplish this result. V., 3424.

of carbon, as given by Morton in terms of the ratio of its resistance to that of mercury, can be expressed in microhms by multiplying Morton's figures by 100. The result will be correct within four per cent. V., 3425

of carbon of filaments in defendant's lamps cannot justly be compared with that of arc light carbons, which are intended to be electro-plated with copper to reduce their resistance; neither can those of defendants' filaments, which have been greatly reduced in resistance by electro-plating with carbon, be properly compared with said arc light carbons before the latter have been electro-plated with copper. Lastly, a comparison of the

RESISTANCE, SPECIFIC—(*Continued*):

specific resistance of the arc light carbons, which are subjected during manufacture to a comparatively low heat, with that of defendants' filaments, which have been greatly reduced in specific resistance by intense heating, is manifestly unfair. V., 3427-8.

of carbon of filaments in defendants' lamps is high, when judged by a proper standard, *i. e.*, arc light carbons made as they are intended to be used, either suitably dense and unplated of 600 to 1,000 microhms specific resistance, or electro-plated carbons of 100 to 600 microhms. V., 3428-9.

Electro-plating of arc light carbon results in obtaining a low specific resistance of the pencil independently of the specific resistance of the carbon alone. V., 3429-30.

of carbon of filaments in defendants' lamps, being five or six times greater than that of the only kind of carbons in use for electric lighting prior to date of patent in suit, is "high" within the meaning of first claim of said patent. V., 3436.

of carbon for arc lighting cannot be too low, and all efforts have been made to secure this end. Such carbon, if of absolutely no resistance, would be ideally perfect. V., 3437.

of carbons most suitable for arc lighting prior to date of patent in suit was 600 microhms. V., 3438.

Table of specific resistance of twenty-nine different arc light carbons (plain and electro-plated or "coppered"), measured by Franklin Institute Committee in 1884. V., 3441-42.

of gas retort carbon is 1723 to 2356 microhms according to Marchand, and 3027 to 3274 according to Beetz. V., 3444.

of any variety of carbon depends upon its density or closeness of aggregation of its particles. V., 3458.

SEALING:

of platinum leading wires into glass walls of lamp chamber by fusion of the glass upon them is referred to in second claim of patent in suit by the expression "conductor passing through the glass." The conductors serve to carry the current to, and lead it from, the filament. I., 71. **284.**

of platinum wires into walls of exhausted glass chamber by fusion of the glass, in order to make tight joint around them, and that such wires were best suited to conduct the current through the walls of the chamber were known prior to 1878. I., 174, **696.**

SEALING—(*Continued*):

Old lamps were made with separable parts which could not be united by fusion, and no attempt was made to seal in leading wires in same manner. I., 177, **707.**

SECOND CLAIM OF PATENT IN SUIT:

"Carbon filaments" should read "carbon filament." I., 71, **281.**

"Conductors" spoken of in claim must be metallic wires. I., 155, **620.**

SERIES:

arrangement of lamps means that they are placed one after the other in circuit of same conductor, so that the current flows through them successively. I., 192, **765.**

SHAPING:

Edison's carbon burner is reduced to required size or made from material already in the proper form and afterwards carbonized, a method of manufacture which is a new and important departure in the art. I., 65, **258.**

Filamentary carbon burner of Edison's lamp, referred to in first claim of patent in suit, is made by first giving the materials the filamentary form, when it can be easily manipulated, and then carbonizing it. This is the only practical way of making a filament. I., 70, **279.**

The material of the filaments of defendants' three (Zigzag, M and Tamadine) lamps was reduced to the filamentary form prior to its carbonization, the same being the process of the patent in suit. I., 72, **286.**

of the material into filamentary form, before carbonization, has nothing to do with the "carbon filament" of second claim of patent in suit. I., 110, **439.**

Reduction of the crude material to the form of pencils or rods, which were afterwards carbonized, was done prior to date of patent in suit. These were used for arc lighting and for burners of incandescent lamps. I., 149, **595.**

The expression "made as described" in first claim of patent in suit refers to shaping the material into filamentary form, and then carbonizing it. I., 149, **596.**

of the material into the filamentary form before carbonization has nothing to do with the fact that after its carbonization the resulting carbon has a high specific resistance. I., 158, **632.**

SHAPING—(*Continued*):

of the material into the filamentary form before carbonization is only done for the purpose of securing a small cross-section to the burner. I., 159, **633.**

into filamentary form, and subsequent carbonization permits selection of suitable material, easily worked into filaments of uniform cross-section, and makes it possible to secure more uniform carbonization throughout their length. At the same time the carbon of high specific resistance produced reduces the size of filament still further. I., 159-60, **636-7.**

into the filamentary form, and subsequent carbonization confer the property of elasticity and flexibility to burner. I., 164, **654.**

STABILITY:

Being elastic and flexible, a carbon filament is not in danger of being ruptured by shocks and expansion. I., 69, **276.**

Vacuum is essential to the durability of a carbon burner. I., 71, **282.**

SUBDIVISION:

made possible by filamentary carbon burner (see, Filament of Carbon has a small radiating surface, etc.). I., 68, **271.**

was at once understood to be solved upon the appearance of the patent in suit, and it was recognized that Edison had produced a lamp having the indispensable requisites of high economy, durability and simplicity. I., 73, **292.**

To make the burner of high enough resistance to obtain economical subdivision in multiple arc, as Edison attempted to do in 1878 in his platinum lamp, is the theoretically correct principle, whether the burner be made of platinum or carbon. I., 80-1, **319-21.**

The physical laws upon which economical subdivision of the electric light in multiple arc depend have been known for a long time, but the conditions necessary to accomplish this were not well known or recognized at date of patent in suit. Schwendler says that, with the same current, the light becomes rapidly dearer as the number of lamps is increased, hence subdivision must result in failure; a statement which shows that, while fundamental laws may be well known, obvious consequences of them may be overlooked. I., 82, **325-6.**

That electrical apparatus in general, if worked in multiple arc, should have a high resistance in order practically to subdivide the current among them, was not well known long prior to date of patent in suit. I., 82, **327.**

SUBDIVISION—(*Continued*):

In 1879, Schwendler said that subdivision must necessarily result in failure, and that incandescent lighting could not become practical, unless a better material than platinum were discovered, out of which to make the burner. It should have a higher melting point, a lower specific weight and heat, and must not combine with oxygen at high temperature. I., 89, **356.**

does not depend upon the question of resistance alone, but is a function of other conditions as well. I., 91, **361.**

"Dividing the light" means production of several small units of light in place of one large unit. I., 191, **763.**

TAMADINE:

is a non-fibrous material, although made from substances originally fibrous. I., 73, **289.**

UTILITY:

Edison's invention was the creation of a new art in lighting by electricity. Upon appearance of patent in suit, it was conceded that Edison had produced an economical, durable and simple lamp, and had solved the problem of subdivision. No single invention in electric lighting has done more to revolutionize methods of household illumination. Edison's lamp, unlike gas, does not corrupt the air, and gives light of practically equal economy. It is unaccompanied by the heat produced by burning gas, and the resulting deleterious effects are absent. While no successful lamp was in use prior to date of patent in suit, lamps made in accordance with Edison's invention came into extensive use and in enormous numbers immediately thereafter, and all lamps now in use are so made. I., 73-4, **291-6.**

VOLT:

is unit of electrical pressure or electro-motive force. One volt is nearly the electro-motive force of one cell of Daniell's battery. I., 192, **766.**

VACUUM:

"Careful experiments convince me that the vacuum in the (Edison) lamp is now within one four-millionth of a perfect exhaustion. The strictures regarding the exhaustion are merely absurd" (Lecture of March 24, 1880). VI., 4227.

can be maintained in Edison's lamp chamber, which is made entirely of glass, closed at all points by fusion of the glass. This chamber is a new and important departure in the art. I., 65, **258.**

could not be maintained in chambers of old lamps, as they were jointed. I., 71, **283.**

BARKER, Prof. George F.

VACUUM—(*Continued*):

is essential to durability of burner and also to economy of lamp, because the current required with a vacuum has to be increased many times to obtain the same amount of light, if the chamber is filled with a gas at atmospheric pressure. I., 71, **283.**

If the old lamps with rod burners of four ohms resistance had been highly exhausted, assuming that an all glass globe could have been used so as render this possible, they would still have required enormous main conductors, if worked in multiple arc. I., 118, **469.**

That the lamp globe be exhausted is a necessary part of the invention covered by first claim of patent in suit. I., 155, **617.**

It was known prior to 1878 that a carbon burner must be protected from action of the air, and that one way to do this was to place it in an exhausted transparent chamber. I., 175, **697.**

WATT:

is the unit of electrical power, or the rate of work. It is the rate at which work is being done in a circuit of one ohm resistance by a current of one ampere. Seven hundred and forty-six watts are equal to one horsepower. I., 192, **768.**

"Carbon wire" is used in patent in suit synonymously with "filament of carbon." I., 167, **666-7.**

BATCHELOR, Charles.

States that he is assistant to Mr. Edison (Interference Record). V., 3146.

ART, HISTORY OF:

There was nothing in the state of the art on January 9th, 1880, which made of any value an instruction to use wood carbon, or charcoal, as an incandescent burner in a lamp. It would not have assisted in the selection of a suitable material, nor aided in its manufacture. If wood carbon had been suggested to us, it would have given us no clue, in view of the state of the art at the time, as to the existence of those qualities that Mr. Edison had to find out with so much experimenting (McKeesport suit). V., 3196-7.

In view of the state of the art on January 9th, 1880, a direction to use an arch or burner of wood charcoal for an incandescent lamp would have implied the use of exogenous wood, such as willow charcoal, or charcoal made of boxwood, or other such woods. Mr. Edison and myself, by reason of our private experiments, were probably much in advance of the general state of the art at that time; but with our experimental knowledge, such a direction would have been of no use at all, as we never succeeded in making a commercial incandescent lamp from exogenous woods. A direction to use, for an incandescent burner, a carbonized fibrous material would have been of no value at all. It was only by tedious experiments that we found in certain materials those particular qualities that proved to be of value. The fibrous quality of many materials is the very quality which destroys their value for incandescent lighting. This is the case with nearly all the grasses and with nearly every wood or woody material that we have experimented on. The statements in the Sawyer-Man patent relating to their having used carbonized paper covered with plumbago would have been of no value. If they had already carbonized paper, it could do no good to cover it with plumbago. If greater surface was wanted, choosing a thicker paper would have given the same result (McKeesport suit). V., 3197-9.

BURNER:

In October, 1877, Mr. Edison experimented with silicon, boron and other metals, hoping to obtain a more durable and unoxidizable substance than carbon for electric lighting. Some of these were placed in multiple arc, and some in series (Interference Record). V., 3152-3.

A burner made of the finer metals, as, for instance, platinum or platinum iridium, would last much longer in the open air or in a poor vacuum than one made of carbon under the same conditions (McKeesport suit). V., 3189-90.

BURNER OF CARBON:

In August or September, 1877, I remember Mr. Edison putting a paper carbon conductor in an incandescent lamp (Interference Record). V., 3148.

The paper carbon burner in Mr. Edison's first incandescent lamp was about three-quarters of an inch long, a sixteenth of an inch wide, and about seven or eight thousandths of an inch thick (Interference Record). V., 3151.

About August or September, 1878, I made a great many carbons, many of of them being of paper. These were to be worked at partial incandescence. Some of them, especially the smaller ones, were raised to incandescence in an exhausted bell jar of an air pump. The thin ones were generally short, being from two to three inches; the thick ones were sometimes as long as six inches. They ranged in diameter from three-sixteenths of an inch to considerably below a thirty-secondth of an inch. The best method was to coat tissue paper with a mixture of lamp-black and tar, and then roll them up very tightly on a flat plate (Interference Record). V., 3154.

In a lamp similar in principle to Mr. Edison's lamp in Patent No. 224,329, were placed paper carbon burners, kept in contact with platinum points by gravity. The lamp was partly incandescent and partly arc, an arc being formed between points and the carbon (Interference Record.) V., 3155.

In August or September, 1878, we made many experiments with hard carbons, wood carbons, and some metals (Interference Record). V., 3158.

In October, 1879, when he had obtained a very perfect vacuum for his lamps, Mr. Edison again suggested using carbonized paper as a conductor, and I accordingly cut a fine filament of paper, which we carbonized and put into a globe. While this was being tried, I also made lamps with loops of carbonized thread, carbonized flax, fine filaments of lamp-black and tar rolled up and baked, and also threads which had been treated with lamp-black and tar previous to carbonization; the most satisfactory at the time being a carbonized paper loop which I had cut by hand (Interference Record). V., 3160.

There were being used at one time at Menlo Park, as many as eight hundred lamps with carbon burners. On October 7th, 1879, we made incandescent conductors from paper tarred, rubbed with tar and lamp-black, and rolled into the shape of a thread. They were wound into a spiral, carbonized, and put into lamps. Also made some of powdered electric light carbon, made into a pasty mass, rolled into threads and placed in lamps. We afterwards made burners from the following carbonized substances: Cotton thread, vulcanized fiber, threads rubbed with tar and lamp-black, soft paper, fish line, fine threads plaited together in strands, soft paper

BURNER OF CARBON—(*Continued*):

saturated with tar, tar and lamp-black mixed with a proportion of lime, different kinds of thread, cardboards, cotton soaked in boiling tar, celluloid, boxwood, cocoanut hair and shell, drawing paper of different grades, spruce shavings, hickory shavings, bay wood shavings, tissue paper, rosewood, fish lines, maple shavings, string, cotton, lamp-wick, punk, cork, and bagging flax. As the result of all these experiments, Mr. Edison produced lamps having the requisite conditions that he had long been looking and working for, viz.: A high resistance incandescent conductor entirely enclosed in a single piece of glass, from which the air had been exhausted to a very high degree (McKeesport suit). V., 3186-8.

Paper carbons were discontinued in the early part of 1880, and after that time whatever paper carbon lamps were made, were for experiment. Lamps sold to the public were entirely made from bamboo fiber, which was, and is now the standard material (McKeesport suit). V., 3190.

The difficulty with paper carbon from a commercial point of view was its average life. Some carbons would last for a long time, but others owing to defects in the paper, caused small arcs in some points, which shortened their life. Their average life, however carefully we might select and carbonize them, was much less than the average life of bamboo fiber when properly selected. Paper carbon for an incandescent conductor is so much poorer than bamboo, that I believe there are no manufacturers or sellers of it in the world to-day (McKeesport suit). V. 3191-2.

It is commonly understood that the U. S. Electric Light Company make a lamp of tamadine, a non-fibrous material. I believe I have read also that in England they use a lamp from a non-fibrous substance, which is squirted through a die into a liquid which precipitates it (McKeesport suit). V., 3234.

CARBON:

Made experiments on the carbonization of several kinds of paper in 1876. Also tried several kinds of wood. These carbons were to be used for resistances, battery carbons, and other things which were to be sold by the Novelty Company. We measured the resistance of those carbons that were to be used for resistances (Interference Record). V., 3147.

In July, 1877, we used carbonized paper in telephones for contact points and diaphragms. In August or September, 1879, I remember cutting out strips of carbonized paper and putting them into an incandescent lamp. Believe the strips were cut from paper carbonized by us in 1876 (Interference Record). V., 3147.

About August or September, 1878, I made a series of experiments to get a good and light (slender) carbon, to be worked at partial incandescence, and made a great many carbons of paper. Some of these, especially the smaller ones, were raised to incandescence in an exhausted bell jar of an air pump (Interference Record). V., 3154.

CARBON—(*Continued*):

So far as liability to oxidation is concerned, carbon compares very poorly with the finer metals when in the open air or in a poor vacuum. A lamp made of platinum would last much longer in a poor vacuum than one made of carbon. In our early experiments Mr. Edison often raised platinum and platinum-iridium burners to incandescence. He also tried small pieces of carbon in the same manner, but they lasted such a short time, that he asked me to put a piece of carbon in a lamp and exhaust the air, so that he could raise it to incandescence in a vacuum. This was done, but the vacuum being imperfect, they did not last long at the brilliant incandescence at which he wished to run them. In the open air this same carbon would not have lasted at all (McKeesport suit). V., 3189 90.

There was no advantage in using paper to make carbon, except that it was easily and cheaply manufactured. It was by no means such carbon as we have now, which by nature is almost perfectly solid, and perfectly uniform, which the imperfections of paper would never allow us to get. I have made lamps for Mr. Edison from almost every conceivable fiber, and from almost all the woods, for some of which I have designed expensive machinery before making them. Mr. Edison's experiments on the grasses and bamboo have been very extensive. He has sent men, at very great expense, to different parts of the world, who have forwarded him large lots of samples of various woods, which have been tested as to availability for incandescent lamps. We have experimented with the exogenous woods, but they are very poor for an incandescent lamp. It is almost impossible to get a perfect carbon from such woods, owing to the fact that there are cross fibers running around the wood, which you are obliged to cut in cutting lengthwise with the grain, leaving a defect in the burner. No manufacturer employs, or to my knowledge ever has employed, burners made of exogenous woods. Exclusive of bamboo, no wood of any description is now being used commercially in the manufacture of incandescent lamps (McKeesport suit). V., 3192-4.

On January 9th, 1880, there was no such substance known to the art as "carbonized paper covered with powdered plumbago" (McKeesport suit). V., 3196.

It is practically impossible to cut from carbonized paper as thin a filament as is to-day used in the Edison incandescent lamp (McKeesport suit). V., 3196.

The direction to use wood carbon, or charcoal, would not at all have assisted us in our experiments as to the selection of a suitable wood for an incandescent burner, and would have given no clue at all as to those qualities that Mr. Edison had to find out experimentally (McKeesport suit). V., 3196-7.

On January 9th, 1880, a suggestion to use wood charcoal as a burner for an

CARBON—(*Continued*):

incandescent lamp would have been of no value, since the natural meaning would have been to use exogenous woods, such as willow, or box-wood charcoal, and these were useless for the purpose. A direction to use a carbonized fibrous material would not have assisted us, since it is the fibrous quality of many materials which actually destroys their value for incandescent lighting. This is the case with nearly all grasses and with nearly every wood or woody material that we have experimented upon. A statement that carbonized paper covered with plumbago had been tried, would have been of absolutely no value. If it were already carbonized, it could do no good to cover it with plumbago. I had already used a carbonized paper burner in a lamp for Mr. Edison, and it would have been of no service to me to have told me to cover it with plumbago (McKeesport suit). V., 3197-9.

In the lamp described in Sawyer-Man Patent No. 317,676, a fibrous or textile carbon would have no advantage as compared with hard carbons, except that it might be easier mechanically to work it. There was no difficulty on January 9th, 1880, in making artificial carbon pencils, such as the Carré pencils, of dimensions identical with the burner shown in the patent (McKeesport suit). V., 3203.

Many forms of paper, blotting paper for instance, are unsuitable for incandescent conductors. If the parts of the filament were heated unequally during carbonization, some parts of the carbon filament would have more resistance than others. This would be detrimental to the lamp, as it would give "spots" in the filament that would be brighter than other parts, and consequently shorten its life (McKeesport suit). V., 3205-6.

I do not find, either in original specification of Sawyer-Man Patent No. 317,676, as filed, nor in the same as issued, any direction, considering the state of the art on January 9th, 1880, sufficient to enable one conversant with the art to select a proper paper for an incandescent electrical conductor. Mr. Edison and myself arrived at the selection of a paper that could be used by long-continued experiments, made with a very large number of different kinds of paper (McKeesport suit). V., 3207.

On January 9th, 1880, the term "carbonized paper," in view of the state of the art, meant paper that had been carbonized (McKeesport suit). V., 3208.

At the time we made paper carbons, we considered them more practicable than any carbons that we had then made, but that did not deter us from looking for something far superior. The best conductor for a commercial incandescent lamp that has been tried commercially, is the bamboo fibre. Mr. Edison found after a long series of experiments that bamboo fibre had that particular quality which he wanted. I do not believe that the fibrous nature of the carbon entered into the question at all, in fact, our experiments show that we had equally as good carbons, at the time of

CARBON—((*Continued*):

their being made, from non-fibrous material, as from any other (McKees-port suit). V., 3222-3227.

I don't think that I can say that we have ever discontinued the making of carbons of lampblack and tar, and they are practicable lamps to the extent that they will give light and burn for a considerable time (McKeesport suit). V., 3229.

All the Edison lamps made by the Edison Company are fitted with conductors made from carbonized vegetable substances cut to a shape and then car-bonized (McKeesport suit). V., 3229.

Mr. Edison never attached much importance to the fibrous quality of paper car-bon. The value that we have found, after long experiments in carbons made from vegetable substances, I believe is due to the fact of their hav-ing small filamentary cells packed very closely together. It took us a very long time to find out those peculiar vegetable fibres that would give us perfect continuity and the most even and dense structure (McKeesport suit). V., 3235.

If we could produce a method of making a carbon, whereby the solid part would be perfectly dense and still be longitudinally cellular, this would be much better than the carbon we now produce from bamboo fibre. The peculiar merits possessed by bamboo, as material for incandescent conductors, do not exist in all vegetable fibrous materials, and in all materials that are manufactured, such as paper, thread, ropes and such material, they do not exist at all (McKeesport suit). V., 3236.

CARBONIZATION:

Mr. Edison and myself carbonized paper in the summer or fall of 1876, for making resistances, battery carbons, and other things which were to be sold to the Novelty Company. Remember carbonizing strips of paper in pieces of gas tubes; also sheets of paper in an old cast-iron box. Re-member carbonizing sheets of tissue paper, Bristol board, and a number of different kinds of wood. These experiments were not continued longer than a fortnight, so far as the Novelty Company was concerned. These experiments of 1876 furnished us with all the information we needed so far as carbonization was concerned (Interference Record). V., 3146-7.

In carbonizing the paper in the gas tubes in 1876, we took a piece of gas tube five or six inches long and about three-quarters of an inch to an inch in diameter. Threads were cut and screw caps fitted on to each end of the tube. One of these caps was fixed and the other could be screwed off. The strips of paper which were to be carbonized were cut into lengths and put lengthwise into the tube, which was afterwards packed full with

CARBONIZATION—(*Continued*):

charcoal. We had one carbonizing tube smaller than this. In these tubes we carbonized principally stiff papers, such as cardboard. The tubes were heated by being put into a common fire and heated red hot, and allowed to cool before taking the carbons out. The paper carbons that I carbonized were generally three and a half to four inches long, about three-eighths wide, and the thickness of an ordinary visiting card (Interference Record). V., 3164-5.

Some of the strips carbonized for exhibits in the interference suit were car-bonized in an iron box about five inches long, about two inches wide and four inches deep. The box was filled to within an inch of the top with pulverized carbon, the strips laid in, and then the remaining space at the top filled with pulverized carbon, which was pressed down upon the strips. The box was sealed with moistened clay, and the weight of the lid was the only pressure upon the powdered charcoal and the strips (Interference Record). V., 3164-69.

If in carbonizing paper for incandescent conductors there was unequal heat-ing of different parts of the carbon filament, the effect would be that some parts of the filament would have more resistance than others. This would be detrimental to the filament, producing "spots" and shortening its life. In carbonizing paper it is necessary to use means for preserving the tension or strain of the fibers composing the paper (McKeesport suit). V., 3206.

I do not find in Sawyer-Man Patent No. 317,676, any indications as to how the paper to be used is to be carbonized (McKeesport suit). V., 3208.

Nothing that was generally known in the art of carbonization on January 9th, 1880, is being used to-day in a commercial Edison lamp. Mr. Edison and I had made special experiments as to the carbonization of paper prior to January 9th, 1880, and I believe our methods of carbonization of incandescent conductors for electric lights were known only to ourselves (McKeesport suit). V., 3210.

CLAMPING:

About October, 1879, we made an incandescent conductor of paper cut in the form of a ring, carbonized, and a small piece of the carbon cut out so as to leave two ends to the imperfect ring. These ends were fastened to the leading wires so as to put it into the lamp. Next we made carbons for incandescent conductors of carbon thread, which we bent into shape and carbonized, after which we attached the ends to platinum conductors to be placed in lamps. There were different methods of fastening these to the platinum wires in order to secure the good connection at the point of contact (McKeesport suit). V., 3187-8.

BATCHELOR, Charles.

COMMERCIAL SUCCESS:

I know of no such lamp as is shown in the Sawyer-Man Patent No. 317,676 having been offered for sale in the market, or having been used commercially in incandescent or other electric lighting (McKeesport suit). V., 3199-200.

DURABILITY:

The average life of paper carbons, however carefully we might select and carbonize them, would not compare at all with the average life of bamboo fiber when properly selected (McKeesport suit). V., 3191.

DYNAMOS:

In the latter portion of 1878, Mr. Edison was experimenting in order to get the best possible dynamo-electric machine (Interference Record). V., 3156.

FILAMENT OF CARBON:

When Mr. Edison had got an apparatus for making a vacuum far superior to anything that we had had before, it occurred to him that carbon, however small, should be able to stand without oxidizing, which it had always done before (Interference Record). V., 3156.

The result of a series of experiments in August or September, 1878, in vacuo, had shown us that, in order to get a high resistance from carbon, it must be cut in an exceedingly fine filament. In October, 1879, when Mr. Edison had got a very perfect vacuum for his lamps, he suggested the use of carbonized paper as a conductor, and accordingly he had me cut a fine filament of paper, which we carbonized and put in a globe. This filament was, I believe, cut straight from paper and bent round previous to putting it into the carbonizing chamber. At the same time that these were being tried, I also made lamps with loops of carbonized thread, carbonized flax, fine filaments of lamp black and tar, rolled up and baked, and also threads, which had been treated with lamp black and tar previous to carbonization. When the first lamp was made having a fine, filamentary carbonized paper conductor from which light was given, (about October 22d, 1879) then we had a system that could compete with gas, and we exhibited it as such (Interference Record). V., 3158-60.

A very small portion only of the bamboo is practically available for the manufacture of carbon filaments for a commercial lamp. This is the most solid part, next to the silicious cuticle, and although the shell is sometimes an inch thick, we can only use a few thousandths of it next to the scale. Of all kinds of bamboo there are only a very few that we can use for making carbons, and these must be of a certain growth and properly seasoned. We had to design special machinery for making filaments from bamboo fibers. The bamboo must be cut exactly lengthwise with the fibers, as if one were cut across, it would materially lessen its avail-

BATCHELOR, Charles.

FILAMENT OF CARBON—(*Continued*):

ability for use in an incandescent lamp. All these things we had to find out by experiment (McKeesport suit). V., 3194-5.

Mr. Edison has experimented upon several thousand endogenous woods and grasses, and bamboo and one or two others are about all that can be used commercially for a filament in an incandescent lamp (McKeesport suit). V., 3195.

It is practically impossible to cut out a filament of carbon, such as is now used in the Edison lamp, from carbonized paper. Its liability to fracture during the operation of cutting would be so great that I doubt very much whether I myself, who am an expert at anything of that kind, would be able to cut more than one in a hundred (McKeesport suit). V., 3196.

HYDRO-CARBON TREATMENT:

As the light from an incandescent conductor is all given off at its surface, and as my experiments have shown that the treatment of an incandescent conductor in a hydro-carbon bath deposits carbon from the hydro-carbon on its surface and in the interstices, I believe that all light would be radiated from the deposited carbon (Interference Record). V., 3163.

In treating the paper carbon, in our experiments, we generally used gasoline, benzine and such vapors, and the carbons were always raised to brilliant incandescence while we were depositing this carbon (Interference Record). V., 3183.

LAMP CHAMBER:

The lamp chamber in Mr. Edison's first incandescent lamp was a Gassiot tube or cascade, a philosophical instrument for showing the discharge of electricity in vacuo. The bulb was exhausted on the plate of an ordinary air pump (Interference Record). V., 3149-50.

Mr. Edison's lamp made about the middle of October, 1879, was composed of an exhausted hermetically sealed globe, wholly of glass, through which two platinum wires projected on the inside, and to which was clamped a carbon conductor made of carbonized paper (Interference Record). V., 3157.

The lamp chamber shown in Sawyer-Man Patents Nos. 317,676 and 205,144 is not made wholly of glass, for if the chamber were made wholly of glass, there would be no tinfoil and cement between the glass stopper and the plate. The cement would soften under the influence of the heating of the lamp (McKeesport suit). V., 3200.

If, as shown in Sawyer-Man patents, the lamp were filled with gas, the heat produced by the incandescence of the lamp would expand the gas, thus putting a greater pressure on the inside of the lamp than on the outside.

LAMP CHAMBER—(Continued):

The heat would soften the Canada balsam, and there would be a tendency of the rarefied gas to escape at the most imperfect part of the joint The reverse would be the case when the lamp was extinguished, and in that case the atmosphere would tend to get in. Moreover, the continued heating and cooling of the interior of the lamp would tend to make a bad joint between the two parts of the lamp globe (McKeesport suit). V., 3201.

It is practically impossible to fuse together the two pieces of glass shown in Sawyer-Man Patent No. 317,676 without damage to the globe (McKees-port suit). V., 3202.

The method shown in the Sawyer-Man Patents Nos. 317,676 and 205,144 is not suitable for closing a lamp chamber of a practical commercial in-candescent lamp. They would get no better vacuum than in the bell of an ordinary common air pump, and could not exhaust the lamp to the de-gree obtained in any commercial incandescent lamp that is at present on the market. If the glass disk were ground to fit smoothly against the flanges of the glass bell and clamped, no matter how tightly, without any connecting cement, it would be impossible to keep an efficient vacuum under the conditions under which an incandescent lamp has to work (McKeesport suit). V., 3202 3.

In the Sawyer-Man lamp, assuming the glass disk to be of equal thickness with the globe of the lamp, although it would not be impossible to fuse the disk to the glass globe, yet a good commercial lamp would never be made that way, as the state of the art at present gives us much better means. A chamber or enclosing globe for an incandescent lamp of one piece of glass, having electrodes passing through holes in the bottom of such lamps was novel on January 9th, 1880, and used only by Mr. Edison (McKeesport suit). V., 3231.

LAMP, INCANDESCENT:

The earliest experiment of Mr. Edison's which I remember in paper carbon conductors in an incandescent lamp, was in August, or September, 1877, though I believe he did some work on an electric lamp in January, 1877 (Interference Record). V., 3148.

Mr. Edison's first incandescent lamp was made from a philosophical instru-ment called a Gassiot tube or cascade, intended to show the discherge of electricity in vacuo. Mr. Edison wishing to try some experiments on in-candescent carbon for lighting purposes, I made the tube into an incan-descent lamp. I put on to this instrument two binding posts, and made two clamps, which I put on to the ends of the rods inside the globe. Mr. Edison wanted at first to use hard carbon, but on account of the great difficulty in making it small enough and getting it into the tube, at his suggestion I cut carbon from carbonized paper and succeeded in giving him a few carbons, at least four, in the lamp. The lamp was placed on

LAMP, INCANDESCENT (Continued):

the plate of an ordinary air-pump and the bulb exhausted, as well as we could do it, with that pump. After that the current was applied to the carbon, which was heated to incandescence for a short time. Should judge the carbons were three-fourths of an inch long, one-sixteenth of an inch wide and from seven to eight thousandths of an inch thick (Interference Record). V., 3149-51.

In the latter portion of 1878, Mr. Edison was almost entirely occupied in experimenting with incandescent lights. He began about this time the improvement of apparatus for getting a good vacuum. He was also endeavoring to get a lamp of high resistance from metals, such as platinum, nickel, iron and alloys of platinum-iridium. This he succeeded in doing in great perfection, but in doing so he had been able to get an apparatus for making a vacuum which was far superior to anything we had before; and it occurred to him that with such a vacuum, carbon, however small, should be able to stand without oxidising, which it had always done before (Interference Record). V., 3155-6.

About the middle of October, 1879, Mr. Edison made lamps composed of a hermetically sealed globe made wholly of glass, through which two platinum wires projected on the inside, and to which was clamped a carbon conductor made of carbonized paper. The globe was exhausted of air (Interference Record). V., 3157.

I know of no such lamp as is shown in the Sawyer-Man Patent No. 317,676 having been offered for sale in the market, or having been used commercially in incandescent or other electric lighting (McKeesport suit). V., 3199-200.

Some of the lamps made of paper carbons were good lamps at the time, so long as we had nothing better, but that we did not consider them the desideratum of electric lighting is shown by the fact that we discarded them in favor of a better material, bamboo fibre (McKeesport suit). V., 3221.

LAMP, SEMI-INCANDESCENT:

About August or September, 1878, I made a series of experiments, in order to get a good and light (slender) carbon to be worked at partial incandescence. The lamp was similar in principle to the lamp described in Mr. Edison's Patent No. 224,329, in which one of these paper carbons was placed directly over six platinum points, and guided in its descent by an upright arm having a projection on it, with a hole through which the carbon could slip. The lamp was both an arc and incandescent lamp, a slight arc forming between the points and the carbon. Provision was made to keep a constant electrical continuity, the carbon standing directly above the platinum or iridium points, and, being free to fall by gravity, always kept in contact with the points (Interference Record). V., 3154-5.

MULTIPLE ARC:

A lamp such as is described in Sawyer-Man Patent No. 317,676, could not have been intended for use in multiple arc (McKeesport suit). V., 3201.

RADIATING SURFACE:

It had been early decided by Mr. Edison that the requisite material for his incandescent lamp should have a great resistance combined with the least possible surface, and experiments in vacuo had shown that in order to get a high resistance from carbon in any form it would have to be cut in an exceedingly fine filament. A great many lamps made during the last of 1878 and up to October, 1879, had their conductors coated with insulating material, so as to be able to wind them up close and get them into as small a space as possible, in order to offer the least radiating surface (Interference Record). V., 3158-9.

RESISTANCE:

In the latter portion of 1878, Mr. Edison was endeavoring to get a lamp of high resistance from metals, such as platinum, nickel, iron and alloys of of platinum iridium. His attention at this time was directed more particularly towards metals rather than carbon for getting his high resistance lamp. This he succeeded in doing to great perfection, but in so doing, he had been able to get a vacuum much superior to any we had had before. It occurred to him that with such a vacuum, carbon, however small, should be able to stand without oxidising, as it had always done before (Interference Record). V., 3156.

It had been early decided by Mr. Edison that the material for his incandescent lamp should have a high resistance combined with the least possible surface, and we expected to get a substance that would give at least 500 ohms resistance. The experiments on platinum led us to expect that we might get a higher resistance from that metal than from carbon. I remember that early in 1879 Mr. Edison remarked that it would be easy to get the desired resistance, provided carbon were stable (Interference Record). V., 3159.

The papers carbonized in the summer of 1876 were tested as to their resistance by Mr. Edison with a Bradley galvanometer. A cheap and high resistance carbon was a desideratum for cable experiments, if it could be made constant (Interference Record). V., 3165-7.

Where lamps are to be used in series, the resistance should be as low as possible (McKeesport suit). V., 3204.

Mr. Edison's search for a material having a high resistance and small surface began long before the use of paper carbon in incandescent lamps. It began when he first discovered that it was possible to subdivide the light by that method (McKeesport suit). V., 3236.

RESISTANCE, SPECIFIC:

Carbons made from carbonized paper would have considerably more resistance than would hard carbon of the same length and cross-section, even when the carbonization is the most perfect (McKeesport suit). V., 3206.

SHAPING:

In the original specification of Sawyer-Man Patent No. 317,676 there is nothing that tends to show that any of the substances were to be shaped to form before carbonization (McKeesport suit). V., 3208.

All lamps made by the Edison Company are fitted with burners made from carbonized vegetable substances, which are cut to a shape, then bent into shape and carbonized (McKeesport suit). V., 3229.

SUBDIVISION:

When Mr. Edison first discovered that it was possible to subdivide the light by means of a material having high resistance and small surface, he began the search for a material having such qualities (McKeesport suit). V., 3236.

VACUUM:

The lamp made in the summer or fall of 1877, from the Gassiot tube or cascade, was put into the plate of an ordinary air pump and exhausted as well as we could do it with that pump (Interference Record). V., 3150.

Some of the carbons, especially the smaller ones made in August or September, 1878, were about that time raised to incandescence in an exhausted bell jar of an air pump (Interference Record). V., 3154.

In the latter portion of 1878, Mr. Edison began the improvement in apparatus for obtaining a good vacuum. These experiments extended far into 1879, and he was able to obtain an apparatus far superior to anything we had had before; and it occurred to him with such a vacuum, carbon, however small, should be able to stand without oxidising, which it had always done before (Interference Record). V., 3156.

At the time of the experiments in the latter part of 1879, Mr. Edison had made lamps with chambers which were entirely of one piece of glass, and by a long series of experiments he had been able to make mercury pumps which would exhaust the air very thoroughly; in fact, equal to anything that is found in the pumps that are used now in manufacturing lamps (McKeesport suit). V., 3189.

A poor vacuum would be fatal to the long life of a lamp made either of a filament of gas carbon, or paper carbon, or bamboo carbon (McKeesport suit). V., 3190.

14

BATCHELOR, Charles.

VACUUM—(*Continued*):

If the method shown in Sawyer-Man Patents Nos. 317,676 and 205,144 were employed for sealing the lamp chamber, no better vacuum would be ob-tained than in an ordinary common air pump, and no such exhaustion would be obtained as is used in any commercial incandescent lamp at present on the market. Grinding and clamping the parts together, however tightly, without any connecting cement, would not overcome the impossibility of maintaining an efficient vacuum under the con-ditions under which an incandescent lamp has to work (McKeesport suit). V., 3202-3.

Previous to the time when Mr. Edison made lamps having glass globes, hermetically sealed (in the sense that we to-day know them to be hermetically sealed), nothing would last when used as an incandescent conductor for any length of time, in such vacuums as we could get then (McKeesport suit). V., 3237).

BERNSTEIN, Alex.

BURNER:

After stating the difficulties experienced with the carbon burners of the old lamps, the author refers to metallic wires, among them platinum, as being especially suited to this purpose. He then describes Edison's platinum lamp and states that " * * * the known forms of construction made by this inventor do not yet by far merit the seal of success." He concludes that, "The feeble electric light has much better prospects if we succeed in obtaining a metallic wire which, by standing a very high heat, is therefore little inclined to destruction, and when the necessary devices are found for preventing this destruction by means of an accurate regulation of the strength of the current" ("Electric Lighting," preface dated Nov., 1879). VI., 4144-7.

DURABILITY:

After describing the semi-incandescent, and incandescent lamp and the principles upon which they operate, the author says of the latter: "The disadvantage of all these lamps lies in the fact that the thin carbon pencil has only a very short life and soon breaks at the weakest point" ("Electric Lighting," preface dated Nov., 1879). VI., 4143.

EVAPORATION:

As to the carbon burners of the old lamps, the author states that, "It is likewise naturally obvious that the carbon pencil is very quickly consumed in the air. To remedy this evil, the carbon pencil has been enclosed in an air-tight glass bell, and later on this has been filled with gases which prevent combustion. But it appears that at a white heat the electric current causes small particles to be thrown off from the carbon pencils obtainable, and thus also, in this case, a pretty rapid wearing out takes place. At all events, the results up to this time do not sound very encouraging" ("Electric Lighting," preface dated Nov., 1879.) VI., 4143.

LAMP, ARC:

"We have already mentioned in the introduction that the electric carbon light, in the form in which we have already considered the same, is not the only kind of light which can be produced by the aid of electricity; there is also another kind of electric lighting to be mentioned in a few words. Up to this time, however, applications to practice with favorable results, have only been made with the arc light, which originates between two carbon rods in the manner described by us, while all other systems are still in the experimental stage" ("Electric Lighting," preface dated Nov., 1879). VI., 4141.

2

BERNSTEIN, ALEX.

LAMP, ARC—(*Continued*):

"At present we must be content to make use of electric lighting by means of an intense light, unless the properties of the electric light, which we have considered in detail, yield additional advantages under other conditions" ("Electric Lighting," preface dated Nov., 1879). VI., 4147.

LAMP, INCANDESCENT:

As distinguished from the arc light, " * * * all other systems are still in the experimental stage" ("Electric Lighting," preface dated Nov., 1879). VI., 4141.

SUBDIVISION:

"The application of the electric light by means of the arc light, alone has claim to be considered in detail, for the reason that this application is confined to it alone, of which, up to this time, very successful practical use has been made. We have finally also briefly mentioned the methods of production by feeble sources of light, which are intended to supplant gas." After referring to results obtained with semi-incandescent and Edison platinum lamps, the author continues: "Thus the closer we approach to these systems, which permit a division of the total amount of light into many feeble light centres, the more unfavorable becomes the ratio between the power required and the light produced. Add to this, that the expense of the carbon rods for the feeble light in relation to the total amount of light produced is considerably greater than is the case with the powerful light. For these reasons, we arrive at the result that a limit to the subdivision of the light is imposed by the known forms of electrical carbon lights, which cannot be overstepped without the excessive cost of operation appearing as a substantial loss. The feeble electric light has much better prospects if we succeed in obtaining a metallic wire which, by standing a very high heat, is therefore little inclined to destruction, and when the necessary devices are found for preventing this destruction by means of an accurate regulation of the strength of the current. * * * If we succeed in overcoming these objections, the electric light of this type has a very important future in those parts of the earth in which motive power is abundantly and cheaply at hand. At present we must be content to make use of electric lighting by means of an intense light unless the properties of the electric light, which we have considered in detail, yield additional advantage under other conditions" ("Electric Lighting," preface dated Nov. 1879). VI., 4146-7.

BORDEN, SPENCER:

Manager of the New England Department of the Edison Company for Isolated Lighting.

COMPETITION WITH INFRINGING COMPANIES:

The agents of the Edison Company, acting under special instructions, find that "in the City of New York there had been made 23 Maxim installations, of which 8, including 634 lights, a large number of which were run free, and 2 having unknown number of lamps (10 in all) were still running at the time of the inquiry. Ten others, 7 having 246 lamps, and 3 an unknown number, had been thrown out all together, and 3 plants rejected and the Edison put in their places. *In New York City 13 out of 23 plants had been rejected because they were unsatisfactory.* Outside of New York were found 21 of their installations (including that of Grant Bros.), permanent or on trial, of which 5 were in mills controlled and run by parties interested in the Maxim light pecuniarily, and these 5 included more than half of all the lights they had in use in the world, outside of New York. As against these seemingly permanent installations we found 9 that had been thrown out because unsatisfactory, some of them replaced by the Edison system.

To recapitulate: There were found 30 plants apparently still alive, and 22 rejected after trial."

The Edison Company had 394 plants running, using over 80,000 lights (of which 274 plants, 60,725 lights, are within the United States), and no plant had ever been taken out from any buyer's dissatisfaction therewith. * * * "From the large number of plants they (Maxim) had rejected, it seemed probable that, if let alone, they would stop without interference here as they had abroad" (Announcement of November, 1883). VI., 4430.

INFRINGEMENT:

"Many of those interested in the Edison Company were urging its officers to deal summarily with parties who were pirates of Mr. Edison's inventions—the Weston-Maxim combination being the most flagrant offenders in that direction, the only valuable parts of their incomplete system being unblushing imitations of Mr. Edison's devices. Before entering suit against these people, the president of the Edison Company sent a circular to his agents, asking for information, so that it might be ascertained if the losses by business going to the Weston-Maxim combinations were of sufficient importance to justify the necessary expenses involved in suing them. The answers of the agents were compiled, and a copy of the accumulated information sent to each agent

2

BORDEN, Spencer.

INFRINGEMENT—(*Continued*):

when the answers were complete." Then follows an account of the Maxim plants and the statements that 30 plants are still in use and 22 have been rejected after trial. "In view of the fact that the Edison Company had 334 plants running, using over 80,000 lights (of which 274 plants, 60,725 lights, are within the United States), and no plant had ever been taken out from any buyer's dissatisfaction therewith, it seemed hardly worth while to spend the time and money involved (beyond serving a formal notice of infringement, which was done) to conduct legal proceedings for the purpose of stopping these parties from prosecuting their business, annoying as it might be for us to let them run. "The game was not worth the candle;" and from the large proportion of plants they had rejected, it seemed probable that, if let alone, they would stop without interference here as they had abroad (Announcement of November, 1883). VI., 4429-30.

BRACKETT, Alonzo C.

Says he is not an electrician. IV., 2684, **10734.**

ADAMS'S LAMP:

In 1873, while I was in the employ of Smith, Phinney & Smith (nickel platers) at 133 and 135 W. Twenty-fifth street, New York, I had charge of the receiving, delivering and billing of goods. My duties were in connection with the office, which was on the first floor. In that year I remember seeing Dr. Adams visit our establishment and that he burned an electric lamp, or lamps, there, in the rear of the building, on the office floor. I did not examine the light or its construction. I recollect the fact of Dr. Adams experimenting with these lamps, or with this lamp; I don't remember the number of lamps. I also recollect that the light was dazzling to the eyes; so dazzling I did not care to look at it. Do not remember of more than one occasion when the lamp, or lamps, were burned. Think that Mr. L. L. Smith, who is now dead, was with Dr. Adams on on this occasion. Dr. Adams left a lamp in our shop which, so far as I know, remained there until two days ago (Oct. 13, 1890). The defendants' Exhibit Adams Lamp No 1, is that lamp. At the time I saw Dr. Adams and his lamp, the only way in which he was interested in our firm was, that we had a license from the United Nickel Company, who were the owners of Dr. Adams' patents in nickel plating. IV., 2682-4, **10726-33.**

DYNAMOS:

The lamp of Dr. Adams which I saw lighted, in 1873, was actuated by a Wilder dynamo which we used in nickel plating. I do not know what electro-motive force it would give. IV., 2684, **10734.**

BRACKETT, Prof. Cyrus F.

BURNER:

"Burner" is not properly applied to Geissler tube. V., 3513.

CANDLE POWER:

The tests of Prof. Brackett and Young, 1880, showed that Edison lamps gave 107 candles per horse-power, delivered to the dynamo. VI., 4246-50.

BURNER OF CARBON:

King's patent shows a removable burner. See V., 3517.

There were no incandescent lamps without removable carbons prior to 1845. V., 3523.

Carbon pencils were used in semi-incandescent lamps prior to 1845. V., 3523.

To secure a good burner, proper wood must be chosen, and then cut along the fiber (McKeesport suit). V., 3545.

Only an exceedingly small fraction of the whole number of vegetable fibers known would do for burners in lamps (McKeesport suit). V., 3546.

Sawyer-Man United States Patent No. 317,676, does not give sufficient directions to enable skilled persons to make a practically operative burner (McKeesport suit). V., 3546.

To secure uniformity of material and homogeneousness of structure in the carbonized material, proper wood must be selected and then cut along the fibers (McKeesport suit). V., 3545.

COMMERCIAL SUCCESS:

Geissler tubes are not fit for general illumination. V., 3514.

CONDUCTORS:

The mercury tubes shown in lamp of Edison's United States Patent No. 237,732, have two offices—to exhaust the chamber, and to act as conductors of the current to and from the incandescing carbon. They must be of considerable size to avoid undue heating by the current. V., 3527.

In King's lamp the copper wire in the tube, rather than the mercury, is the principal and most efficient conductor. V., 3528.

CONDUCTORS—(*Continued*):

Gases, including air, are sometimes called imperfect conductors, but the work of Sir Wm. Thomson and Clerk Maxwell leave no room for doubt that gases are perfect insulators. V., 3547.

A lower conductor of platinum sealed into the glass in King's lamp would render the lamp impracticable. V., 3549.

CROOKES'S RADIOMETER:

Crookes's radiometers are used to show the mechanical effects due to molecular encounters taking place in gases in a highly rarefied condition, and these produce rotation or displacement. V., 3520.

Crookes,s radiometers are composed of a light, thin body, such as mica, suspended by a delicate spring in an exhausted air chamber. The body suspended should be blackened on one side. When a body emitting radiations is presented to the mica, it will be displaced, and by joining several thin plates of mica on a perpendicular axis, continuous rotation will result. V., 3520.

The platinum wire in Crookes's radiometer is designed to be connected to a source of electrical energy so as to become heated, and by its radiation operate the radiometer. V., 3520.

The sealing of Crookes's radiometer would not have suggested hermetically sealing incandescent lamps, since it was considered necessary to allow the removal of the carbon. V., 3521.

has never been employed for electric lighting. V., 3521.

Crookes's radiometers probably had a vacuum much higher than many commercial incandescent lamps of the present day. V., 3539.

DURABILITY:

Lack of durability prior to Edison's work was owing to imperfection in manufacture of burner, leakage of chamber, want of means for obtaining high enough vacua, and lack of uniformity in the incandescing carbon. V., 3539.

The carbon in old lamps held air in its cavities, which, on the carbon becoming incandescent, was given off, hastening destruction of lamps. V., 3541.

DYNAMOS:

In their tests of the efficiency of Edison dynamos, Profs. Brackett and Young obtained a mean total efficiency of 83.8 per cent. and a mean available efficiency (that is, for useful work) of 78.4 per cent. Upon certain assumptions they give the total efficiency as 89.9 per cent., and

DYNAMOS—(*Continued*):

the available efficiency as 84.1 per cent., and state that "the figures, we believe, fairly represent the performance of the machine in its present condition." In the machine tested the armature resistance was 0.14 of an ohm, and that of the rest of the circuit (external circuit) was varied from 1.9 to 3.2 ohms. They also tested an Edison lamp, and state that 107 candles of light are obtainable for each horse-power delivered to this dynamo (Brackett and Young tests, May 15, 1880). VI., 4246-50.

ECONOMY:

In 1880 there was a positive and very considerable advantage in favor of electric light compared with gas, illumination being equal, when efficient dynamos and proper lamps and lamp circuits were employed. V., 3522.

EFFICIENCY:

In their tests of the efficiency of Edison's dynamo, Profs. Brackett and Young obtained a mean total efficiency of 83.8 per cent. and a mean available efficiency (that is, for useful work) of 78.4 per cent. Upon certain assumptions they give the total efficiency as 89.9 per cent. and the available efficiency as 84.1 per cent., and state that "the figures, we believe, fairly represent the performance of the machine in its present condition." In the machine tested the armature resistance was 0.14 of an ohm, and that of the rest of the circuit (external circuit) was varied from 1.9 to 3.2 ohms. They also tested an Edison lamp, and state that 107 candles of light are obtainable for each horse-power delivered to this dynamo (Brackett and Young tests, May 15, 1880). VI., 4246-50.

Tests made by Brackett & Young show the efficiency of Edison machine in 1880 to be not less than 78%., a result favorable to economy of incandescent lighting. V., 3522.

FILAMENT:

Capillary bore of Geissler tube is not a filament, since the operation is different. V., 3511.

GASES:

Gases in Geissler tube are not "heated," in any proper sense of the term, during passage of the spark. V., 3533.

Prior to Edison it was not well understood that other gases than oxygen must be excluded from incandescent carbon lamp. V., 3539.

GEISSLER TUBES:

are made of glass of various lengths and shapes. Electrodes project into the cavity, and are fused into the glass. Means are provided for exhausting and sealing hermetically. Connected with high potential source of electricity, and the illumination depends upon nature of gas and degree of exhaustion to which the tube has been subjected. V., 3508.

BRACKETT, Prof. Cyrus F.

GEISSLER TUBES—(*Continued*):

are used in spectroscopic research. Special forms have been proposed and used to some extent in surgery. Have been proposed for use in mines and submarine explorations. V., 3508.

are not incandescent lamps, and the light is due to disruptive discharge. Temperature of gas is not raised sufficiently to produce light by incandescence. V., 3509.

Attenuated gas in Geissler tubes is not a conductor of high resistance. V., 3509.

Light in Geissler tubes is due to molecular encounters carrying electricity from one point to another by convection, hence there is no proper conduction. V., 3511.

Experiment shows that Ohm's law is inapplicable in Geissler tubes. V., 3511.

Fact that bore of Geissler tubes is capillary does not make it a filament. V., 3511.

Passage of electricity between the electrodes in Geissler tube is "disruptive;" between the molecules it is "convective." V., 3512.

Fluorescence in Geissler tube is not incandescence. V., 3512.

The term "burner" not properly applied to Geissler tube. V., 3513.

Geissler tubes are not suitable for purposes of "illumination," in the sense of commercial illumination, and when cited in reference to this use, are pronounced unfit by the authorities on the subject. V., 3514.

Principles involved in construction of Geissler tubes are not applicable to incandescent lamps prior to those of Edison, because the latter were made so as to be taken apart and allow the renewal of the burner, making it impossible to maintain a suitable vacuum. V., 3515.

Construction of Geissler tubes would not have suggested hermetically sealing incandescent lamps, since it was considered necessary to allow of removal of incandescing carbon. V., 3521.

Air-tight joints made by sealing platinum into glass had been used prior to 1880. V., 3530.

If every trace of air or gas were removed from a Geissler tube no current would pass, as the gas facilitates the passage of the current. V., 3532.

BRACKETT, Prof. Cyrus F.

GEISSLER TUBES—(*Continued*):

A Geissler tube connected to a source of electric energy, on being exhausted, allows the spark for a time to pass with greater facility, as the exhaustion proceeds. But a point is reached beyond which the spark passes less easily, and finally ceases to pass at all. These observed changes in the action of Geissler tubes to some extent depend upon the nature of the gas. V., 3532.

The gas in Geissler tube is not "heated," in any proper sense of the term, by passage of the current. V., 3533.

Gases, including air, are sometimes called imperfect conductors, but the work of Sir Wm. Thomson and Clerk Maxwell leave no room for doubt that gases are perfect insulators. V., 3547.

Fluorescence is not a property peculiar to Geissler tubes. V., 3547.

INVENTION INVOLVED:

There is no invention involved in using platinum sealed into the glass as lower connection in King's lamp (McKeesport suit). V., 3530.

KING'S LAMP:

The words in King's patent, "fixed into the piece at *h*," indicated that the copper wire was to be permanently secured to piece *h*. V., 3524.

King plainly endeavored to provide a lamp chamber which would permit the renewal of the burner and not make it necessary to throw away the entire structure when the burner failed. V., 3524.

Decreased diameter of bulb in Fig. 2 of King's patent is owing to inadvertence of draughtsman. Patentee intended removal of parts, otherwise no useful purpose would be served by the construction in that particular manner. V., 3526.

The mercury tube in King's lamp, except for removal of parts, might be ¼ in. or less in diameter. V., 3527.

Mercury tube in King's lamp is not shown large because the mercury is to form part of the circuit, for if this were large, there would be no use for the introduction of the copper wire, which is the principal and most efficient conductor of the current through the tube. V., 3528.

The mercury in King's lamps served the purpose of "mercury cups," a well-known means of joining up electric circuits. V., 3528.

"Suitably sealed," is to be understood to mean "hermetically closed," in King's patent (McKeesport suit). V., 3529.

KING'S LAMP—(*Continued*):

Since there is a copper wire at the bottom, and the Toricellian vacuum is employed, the lower wire cannot be sealed to the glass by fusing the latter, as is done with the upper platinum wire (McKeesport suit). V., 3530.

King's lamp, if used for submarine lighting, might be sealed with mercury, as is done in barometers (McKeesport suit). V., 3530.

Invention would not be required to substitute platinum wire in King's lamp for lower connection, and to seal as is done with upper wire (McKeesport suit). V., 3530.

The construction of King's lamp prevented his obtaining therein the highest vacuum known in his day. V., 3541.

The use of platinum wire for lower conductor in King's lamp, and sealing the glass chamber above the mercury, would not be useful, for it would render the expensive apparatus useless after a short period, and make such a lamp impracticable. V., 3549.

LAMP CHAMBER:

Prior lamps were constructed so as to allow of being taken apart to permit the renewal of the incandescing portion. V., 3515.

Lamp described in King's specification could not be useful, as the vacuum, assuming that the lamp was sealed, would be too imperfect for continuous operation for considerable period. V., 3517.

Lamp chamber in King's lamp could not be sealed, as is now done, since the coefficients of expansion of copper and glass are greatly different. V., 3518.

To produce Toricellian vaccum in King's lamps, the walls of the tube must be so thick as to render sealing off the upper part of the tube by fusion with a blow-pipe impracticable. V., 3518.

That the incandescing carbon and all supporting apparatus are intended to be removable is shown by mention of "screws" in King's specification. The copper wire is for this purpose, and the width of the tube joined to the lamp chamber is shown sufficiently wide to permit of removing the carbon and its support. V., 3519.

Crookes's radiometer and Geissler tubes would not have suggested sealing incandescent lamp chamber by fusion of the glass. V., 3521.

That the tube at the base of chamber in Fig. 2 of King's patent is shown smaller than necessary for removing parts, is due to inadvertence of draughtsman. V., 3526.

LAMP CHAMBER—(*Continued*):

In King's lamp some other method of sealing is contemplated than by fusing the glass and lower conductor together (McKeesport suit). V., 3530.

King's lamp for submarine lighting might be sealed with mercury, as is done in barometers (McKeesport suit). V., 3530.

Leakage was a defect in all incandescent lamps prior to Edison. V., 3539.

The use of separable chambers in early incandescent lamps was dictated by the desirability of replacing worn out carbons, rather than from lack of knowledge how to seal up globes and obtain high vacua. V., 3542.

Early lamp chambers were necessarily made bulky, heavy, and with thick walls and tubes, as best suited to the means of exhaustion then known and employed. V., 3542.

Lamp globe shown in Roberts's patent is probably three inches and a half in diameter. V., 3542.

LAMP, INCANDESCENT:

Geissler tubes are not incandescent lamps. V., 3509.

Prior lamps contemplated renewal from time to time of the incandescent body. Edison contemplates the abandonment of structure when the period of usefulness of the burner is passed. V., 3516.

The mention of "screws" in King's specification makes it evident that the incandescing carbon and all the supporting apparatus is attached to the lower end of the platinum wire by a screw joint, so as to be detached and removed, and the copper wire is provided for that purpose. This is further confirmed by the width of the tube joined to the lamp. V., 3519.

No descriptions of incandescent lamps without removable carbons are found prior to date of King's patent, 1845. V., 3523.

Platinum wire burners were used in incandescent lamps prior to 1845. V., 3523.

Prior to 1845, incandescent lamps had no glass chamber. They were of platinum or other metal rendered incandescent, or were semi-incandescent, in which pencils of carbon were in contact and incandescent. They were only experimental. V., 3523.

Removable burner is an essential feature in King's lamp, and his lamp was so made on economical grounds. V., 3524.

BRACKETT, Prof. Cyrus F.

LAMP, INCANDESCENT—(*Continued*):

Shortness of life in incandescent lamps prior to Edison was due to imperfection in manufacture of burner, leakage of globe, want of means for producing suitable vacua, and lack of uniformity in incandescing carbon. V., 3539.

LEADING WIRES:

No invention would be involved in using platinum for lower connection in King's lamp and fusing it into the glass (McKeesport suit). V., 3530.

Platinum for lower conductor sealed into the glass in King's lamp would render the lamp impracticable. V., 3549.

MERCURY TUBE:

The mercury tube in King's lamp would depend in size upon the copper wire employed. It might be ¼ in. or less in diameter. V., 3527.

Mercury tubes in Edison U. S. Patent No. 237,732, are not shown too large, since the mercury has two offices—viz., to exhaust the chamber, and to act as conductors of the current to and from incandescing carbon. Mercury columns must have considerable size to avoid undue heating. V., 3527.

Mercury in King's lamp serves the purpose of "mercury cups," a well-known means of joining up electric circuits. V., 3528.

RESISTANCE:

Attenuated gas in Geissler tubes is not a conductor of high resistance. V., 3509.

SEALING:

Sealing of incandescent lamp chamber by fusion of the glass would not be suggested by Crookes's radiometer and Geissler tubes. V., 3521.

"Hermetically closed" is to be understood as meaning the same as "suitably sealed" in King's Patent No. 10,919, of 1845 (McKeesport suit). V., 3529.

The lower copper wire in King's lamp is not intended to be sealed into the glass by fusing the latter, as is done with the upper platinum wire (McKeesport suit). V., 3530.

In King's patent some other method than fusing the glass for purpose of sealing the lamp is contemplated (McKeesport suit). V., 3530.

Sealing platinum wires into glass to obtain air-tight joint has been known for forty or fifty years (McKeesport suit). V., 3530.

BRACKETT, Prof. Cyrus F.

SEALING—(*Continued*):

Fused joints between platinum and glass had been used prior to 1880 in eudiometric apparatus for analysis of gas, in apparatus for decomposing liquids electrolytically, in Geissler tubes, etc. (McKeesport suit). V., 3530.

If King's lamp had platinum as lower conductor sealed into the glass, it would be impracticable. V., 3549.

SHAPING:

To secure uniformity and homogeneousness of structure in the carbonized material, proper wood must be selected and then cut along the fibers (McKeesport suit). V., 3546.

Sawyer-Man Patent No. 317,676, does not give such directions as to selection and preparation of material for making burners as would enable one, without further experiment, to produce operative burner (McKeesport suit). V., 3546.

UTILITY:

The use of platinum wire for lower conductor in King's lamp, and sealing the glass chamber above the mercury, would not be useful, for it would render the expensive apparatus useless after a short period and make such a lamp impracticable. V., 3549.

Geissler's tube are not suitable for purposes of "illumination," in the sense of commercial illumination, and when cited in reference to this use, are pronounced unfit by the authorities on the subject. V., 3514.

VACUUM:

It was impossible to maintain a suitable vacuum in lamps prior to Edison. V., 3515.

The vacuum in King's lamp was too imperfect to be long serviceable. V., 3517.

No special description of the apparatus to produce a vacuum in King's lamp is given or needed. V., 3525.

Torricelli's vaccuum, as proposed by himself, was not the best attainable vacuum in 1845. To obtain the best practicable vacuum known at that time, the tubes should be carefully cleaned, and the mercury must be boiled, to exclude the air. V., 3531.

It was recognized prior to Edison that it was necessary to remove oxygen from incandescent lamps using carbon, but not so well known that other

BRACKETT, Prof. Cyrus F.

VACUUM—(*Continued*):

gases must be excluded. No means for producing a really high vacuum were at hand before the invention of Geissler & Sprengel pumps. V., 3539.

Crookes's radiometers probably had a vacuum much higher than many commercial incandescent lamps of the present day. V., 3539.

Lack of durability prior to Edison's work was, among other things, owing to leakage of air into lamp chamber. V., 3539.

One-millionth of an atmosphere is a high vacuum at present. In ordinary pneumatics one hundred-thousandth of an atmosphere would be a high vacuum, and the latter would be high compared with the older and earlier practice of electric lighting. V., 3540.

A barometer tube may to-day be so thoroughly exhausted, that when the mercury rises it completely fills the tube. V., 3540.

In 1845, the Torricellian vacuum, taking proper precautions, was certainly better than that obtained by using air-pumps. V., 3541.

King could not have secured with his construction of lamp the best vacuum obtainable in his time. His copper, had he tried to boil his mercury, would have been destroyed by amalgamation, and his carbon would have retained air in its cavities, soon destroying the lamp. V., 3541.

BRADLEY, Circuit Justice.

BURNER OF CARBON:

"We are clearly of opinion, therefore, that neither Sawyer and Man nor Edison can maintain any just claim to the exclusive use of charcoal generally, in any form, as an incandescing conductor in an electric lamp" (McKeesport suit). I., 389, **1554.**

EDISON'S LAMP:

Discovery: " * * * The great discovery in the art was that of adopting high resistance in the conductor with a small illuminating surface, and a corresponding diminution in the strength of the current. This was accomplished by Edison in his filamental thread-like conductors, rendered practicable by the perfection of the vacuum in the globe of the lamp. He abandoned the old method of making the globe in separate pieces, cemented together, and adopted a globe of one entire piece of glass, into which he introduced small platinum conductors fastened by fusion of the glass around them, thus being able to procure and maintain, perhaps, the most perfect vacuum known in the arts. In such a vacuum the slender filaments of carbon, attenuated to the last degree of fineness, may be maintained in a state of incandescence without deterioration for an indefinite time, and with a small expenditure of electric force. This was really the grand discovery in the art of electric lighting, without which it could not have become a practical art for the purpose of general use in houses and cities. * * * The principal and great thing described (in Edison's patent—the patent in suit) is the attenuated filament, and its enclosure in a perfect vacuum. * * * We think we are not mistaken in saying that but for this discovery electric lighting would never have become a fact. We have supposed it to be the discovery of Edison, because he has a patent for it. This may not be the case; it may be the discovery of some other person. But, whoever discovered it, it is undoubtedly the great discovery in the art of practical lighting by electricity" (McKeesport suit). I., 394-8, **1576-8** and **1588-9.**

PATENT IN SUIT:

Filament: "Of course the form of the filament in the receiver or globe may be varied at pleasure; it may be in the shape of a coil, or of a horseshoe, or it may be wound on a bobbin. All these forms are old. The principal and great thing described is the attenuated filament and its enclosure in a perfect vacuum. There may be a preference of material from which the filament is made. Practice will evolve all these collateral advantages" (McKeesport suit). I., 397, **1588.**

SAWYER-MAN LAMP:

History: "Their principal experiments were made in 1879. The evidence as to what they accomplished in the construction of electric lamps is so contradictory and suspicious that we can with difficulty give credence to the conclusions sought to be drawn from it" (McKeesport suit). I., 393, **1571.**

History: During the year 1878 and the beginning of 1879, Sawyer and Man obtained ten different patents on the subject of electric lamps, all of which relate to lamps with straight-pencil burners, generally of carbon, but without any preference for one kind of carbon over another. None of the patents contain a hint of any such invention as is claimed in their Patent No. 317,676, which was not applied for until January, 1880, nearly or quite a year after all their experiments had ceased, and after the inventions of Edison had been published to the world. "One cannot read the patents before applied for by Sawyer and Man, with all their detail of apparatus and process for constructing and managing the straight stem conductors, without distinction of carbons—apparatus and process many of which would be needless in the lamp now claimed by Sawyer and Man—without indulging some degree of astonishment at the pains and ingenuity gratuitously expended or wasted, if it was true that, all the time, they had in their possession a secret invention which would take the place of those complicated contrivances. The explanations made by the complainants (The Consolidated Electric Light Company) for the delay in applying for the patent in suit (Sawyer-Man Patent No. 317,676), fail to satisfy our minds that Sawyer and Man, or their assignees for them, have not sought to obtain a patent to which they were not legitimately entitled" (McKeesport suit). I., 393-4, **1572-4.**

Commercial Success: "We are not at all satisfied that Sawyer and Man ever made and reduced to practical operation any such invention as is set forth and claimed in the patent in suit (No. 317,676). * * * We are not satisfied that they ever produced an electric lamp with a burner of carbon made from fibrous material, or any material, which was a success" (McKeesport suit). I., 393, **1571-2.**

Principle Wrong: "Did they (Sawyer-Man lamps, with arched-shaped, fibrous carbon burners) go any farther in principle, if they did in degree, than other lamps which had been constructed before? It seems to us that they were following a wrong principle, the principle of small resistance in an incandescing conductor, and a strong current of electricity." * * * (McKeesport suit). I., 394, **1576.**

Utility: "But suppose it to be true, as the supposed inventors (Sawyer and Man) and some of the other witnesses testify, that they did, in 1878, construct some lamps with burners of carbon made of fibrous material and of an arched shape, which continued to give light for days, or weeks, or

SAWYER-MAN LAMP—(*Continued*):

months; still were they a successful invention? Would any one purchase or touch them now? Did they not lack an essential ingredient which was necessary to their adoption and use?" (McKeesport suit). I., 394, **1575.**

Utility: Sawyer and Man "may have made a lamp that would burn; but was it a success, or was it a failure? Did it ever go into use? What was the object of all the experiments made by them and others? Was it not to make an electric lamp that could be successfully used by the public and have a commercial value? Did they succeed in making such a lamp, or in finding out the principle upon which it could be made? We do not so read the evidence" (McKeesport suit). I., 398, **1589-90.**

SAWYER-MAN PATENT:

Scope Enlarged: "We have carefully compared it (the original application) with the amended application on which the patent (No. 317,676) was issued, and are fully satisfied that after Edison's inventions on this subject had been published to the world, there was an entire change of base on the part of Sawyer and Man, and that the application was amended to give it an entirely different direction and purpose from what it had in its original form. * * * They say distinctly: 'Our improvement consists in the employment of an incandescent arc of carbon in the circuit as the light giving medium,' 'carbon' generally, not any particular carbon. By an adroit amendment, made in 1885, they say: 'Our improvements relate more especially to the incandescing conductor, *its substance*, its form, and its combination with the other elements composing the lamp.' The purpose of this amendment is obvious, and it needs no comment. * * * This is the whole of the original application, except the formal introduction. The arc is everything. The changes are rung on the arc. The fact is, that Sawyer and Man were unconscious that the arc was not new, and supposed that they could get a patent for it; but as their eyes were opened, they changed about and amended their application, and made the material of the conductor the great object, carbon made from fibrous or textile material. * * * The carbons mentioned in the original application are merely mentioned by the way to show that the arched form would apply to all kinds of carbon. * * * The idea of claiming carbons made from fibrous and textile materials was an afterthought, and was no part of the purpose of the original application. The amendments relating to this new and broad claim were made afterwards, in February and March, 1885" (McKeesport suit). I., 389-93, **1555, 1557, 1561, 1562** and **1570.**

BROADNAX, Amos:

is a lawyer. In 1878 was retained by Mr. Man and Mr. Sawyer as solicitor for the Electro-Dynamic Light Company (II., 991), who were the assigns of Sawyer & Man (II., 1004); acted as attorney for Sawyer & Man in their Interference Case with Edison (II., 1013).

BURNER OF CARBON:

The French carbon pencils that I saw used, in 1878, in the Sawyer-Man lamps varied in size from that of an ordinary knitting needle to a large-sized knitting needle. I should say the smallest were about $\frac{1}{32}$ of an inch in diameter. The largest were about $\frac{1}{16}$ of an inch. The length was three-quarters to three-eighths of an inch. II., 988. **3950-1.**

The Sawyer-Man lamp seen by me at their shop on Walker Street, in October or November, 1878, had two forms of illuminants. The one form was a straight pencil of carbon, and the other a U-shaped carbon. The straight illuminant was composed of what is known as treated carbon, or pure deposit carbon. In the U shape, the carbon was made of paper cut to size and shape, then carbonized, and more or less treated before being put into the lamp. In some cases the original carbon pencils were made of some fibrous material cut to size, carbonized, and then treated as described in Sawyer-Man Patent No. 211,262. The fibrous part of the carbon was afterwards removed, leaving a straight shell, either in the form of a tube or in the form of a trough of pure deposit carbon. In the case of the straight pencil, it was a common practice for them to make the illuminant by treating it slightly, preparatory to using it in the lamp, leaving the fibrous carbon intact as part of the illuminant. In December, 1878, I think, I saw some of the lamps with arch-shaped carbons, made of paper or fibrous material, at Mr. Sawyer's house in Fifty-fourth street (McKeesport suit). II., 992-5. **3966-79.**

The paper carbons that I saw taken from the carbonizing retort at Sawyer & Man's shop on Walker Street, were of a great variety of shapes. Some were straight pieces of carbon cut from drawing paper. Some were in the form of a circular washer, a complete ring, having a small section broken out. Some of them were in the form of a bow or loop of irregular form. Carbons were discussed which were made of other materials, such as broom-corn, willow twigs, a great variety of wood, hemp, manilla and cotton thread. I cannot say that I saw any of these materials carbonized and used in lamps (McKeesport suit). II., 998-9. **3990-5.**

I was, in October, 1878, in doubt as to whether there was patentability in an incandescent carbon conductor made of fibrous or textile material, irrespective of its form or combination (McKeesport suit). II., 1001. **4001-2.**

BURNER OF CARBON—(*Continued*):

Immediately after November 5th, 1878, I saw, at the shop of Sawyer & Man, in Walker Street, a lamp fitted with a U-shaped carbon illuminant. Whether the carbon was made of paper or not, I do not know. I did not see it made, nor did I have the carbon in my hand (Interference Record). II., 1014-5. **4056-8.**

The arch or U-shaped carbons, as well as straight carbons, which I saw in Sawyer-Man lamps in October and November, 1878, were made by depositing carbon from a carbonaceous fluid upon a core made of fibrous carbon, and then removing the core, so as to leave an illuminant of the deposited carbon (McKeesport suit). II., 1032. **4125-6.**

In the fall of 1878, I saw Mr. Sawyer putting carbons into lamps. They were straight carbons at one time, and U-shaped, or bow-shaped carbons at another. What the carbons were made of I do not know of my own knowledge. I merely inferred that the bow-shaped carbons were all fibrous carbons. I saw bow-shaped carbons that had not been treated at all, but whether they were treated before being put in the lamps I do not know (McKeesport suit). II., 1052-3. **4206-4210.**

I never saw any paper carbons or fibrous carbons put in the lamps that I knew to be fibrous carbons, except as I was informed by Sawyer & Man, or by Mr. Sawyer's father. I don't know whether old Mr. Sawyer said they were willow carbons or paper carbons. The dug-out carbons I did not see made, and did not see the operation of digging out the core (McKeesport suit). II., 1054-1057. **4213, 4218, 4225-6.**

CARBONIZATION:

The carbonizing retort which I saw at Sawyer & Man's in 1878, was of iron or clay, about four inches long and two inches or two and a half in diameter. Mr. Wm. Sawyer told me that the retort was first charged with a layer of powdered charcoal, which was pressed down to a smooth surface, upon which the material to be carbonized was laid. Another course or layer of the material to be carbonized was then put in the retort, and another layer of powdered carbon put in, and so on till the retort was full. When taken out of the furnace some of the carbons were soft and only partially carbonized, but they were sufficiently carbonized, as Mr. Sawyer explained to me, to enable him to get a current through them in the hydro-carbon treating apparatus (McKeesport suit). II., 996-7. **3984-8.**

CLAMPING:

In the Exhibit Sawyer-Man-Broadnax Lamp, No. 2, the two ends of the bow-shaped illuminant are slipped down into the divided ends of the carbon holders, and were there fastened by some sort of carbonaceous cement. The bow or arch of the illuminant projected above the holders (McKeesport suit). II., 999. **3994-5.**

CLAMPING—(*Continued*):

About October 14th, 1878, Sawyer & Man showed me a lamp in which there was an arch-shaped carbon, each end of said carbon being connected to a leading wire. The arch-formed carbon made of paper was set and cemented with some sort of carbonaceous cement (McKeesport suit). II., 1008-9. **4030** and **4033.**

The clamps for the bow-shaped carbons in the lamps seen at Sawyer & Man's, in the fall of 1878, were made of two pieces of carbon set vertically on top of a leading conductor, and held together by a screw passing transversely through the two parts that composed the clamp. The screw drew the two parts of the clamp together upon the ends of the illuminating conductor, substantially as described in Patent 317,676 (McKeesport suit). II., 1053, **4211.**

COMMERCIAL SUCCESS:

I don't know whether such lamps as I saw at Sawyer & Man's in 1878 and 1879 were ever sold or used commercially (McKeesport suit). II., 1069, **4275.**

CROSS-SECTION:

The French carbon pencils that I saw used in the Sawyer-Man lamps in 1878, varied in diameter from that of an ordinary to a large-sized knitting needle. The smallest were about $\frac{1}{32}$ of an inch, and the largest $\frac{1}{16}$ of an inch in diameter. The carbons produced by Mr. Man I should judge to be $\frac{1}{4}$ of an inch in diameter. II., 988, **3950-1.**

DURABILITY:

On my visit to Sawyer-Man's shop, at Howard Street, in June or July, 1878, I saw a lamp illuminated about half an hour altogether. I did not see any arch-shaped conductors in any lamps there (McKeesport suit). II., 1026-7, **4103** and **4108.**

The longest time that I ever saw the Sawyer-Man lamps illuminated, I don't think was over an hour (McKeesport suit). II., 1070, **4278.**

I do not know how long the Sawyer-Man lamps would last without burning out the carbons, or how long they would last without requiring a recharging of the globes. All the knowledge I have on that subject is mere hearsay information (McKeesport suit). II., 1071, **4283.**

ECONOMY:

I do not know anything about the economy of operation of the Sawyer-Man lamps (McKeesport suit). II., 1071, **4284.**

GASES:

As Sawyer & Man had no pump that would give them an effectual vacuum, they adopted an atmosphere of pure nitrogen for the gas in the chamber of their lamp, which atmosphere they could make more or less attenuated, as practice might seem to require, to ensure a satisfactory lamp (McKeesport suit). II., 1009, **4034.**

HYDRO-CARBON TREATMENT:

The apparatus used for treating the Sawyer-Man carbons consisted of a glass globe, to the bottom of which a disk of glass was ground and sealed. Into this globe projected two leading wires, having clamps, to which the illuminant to be treated was fastened. The globe was filled with hydro-carbon gas or fluid, and an electric current was sent through the carbon, and continued until it was treated to the degree required, the carbon during the treatment being raised electrically to high incandescence (McKeesport suit). II., 996, **3981-4.**

In the fall of 1878, at the shop of Sawyer & Man, I saw bow-shaped carbons that had not been treated at all, but whether they were treated before being put in the lamps or not, I do not know (McKeesport suit). II., 1053, **4210.**

INVENTION INVOLVED:

Two or three days previous to October 14th, 1878, Mr. Sawyer and Mr. Man came to my office with the inventions mentioned in the assignment to the Electro-Dynamic Light Co., asking me to file applications for patents and make the assignments to the Electro-Dynamic Light Company. At that time I was very much in doubt as to whether a patent could be obtained for the incandescent conductor made of fibrous or textile material, irrespective of its form or combination. I finally made a rough draft of an application covering this point, and handed it in April, 1879, to Mr. Sawyer for his suggestions. Mr. Sawyer took the draft and I have never seen it since. In November or December, 1879, Mr. Man asked me about the draft of the specification I had given to Mr. Sawyer. I don't remember any further conversation with Mr. Man until the Sunday morning following the publication in the "New York Herald," describing Mr. Edison's invention of his electric lamp and the use of fibrous or paper carbon. I called Mr. Man's attention to the article and urged the importance of an application for a patent at the earliest possible moment. That was the last interview with Mr. Man upon the subject until the day the application was executed at the office of Chas. A. Cheever (January 9, 1880) (McKeesport suit). II., 1000-7, **3998-4027.**

NOTE. About February, 1885, after the decision in the Interference Case, Mr. Broadnax changed his opinion as to the patentability of fibrous or textile carbon as such. Mr. Man, in testifying in the suit brought against the Edison Company upon U. S. Patent No. 211,262, says that the reason why Mr. Broadnax did not take out the patent in 1878 was to allow for

INVENTION INVOLVED—(*Continued*):

further experiments, and when asked why Mr. Broadnax advised further experiments, Mr. Man is directed by Mr. Broadnax, then his counsel, not to answer. Vol. II., 1079-82, **4312-4326.**

LAMP CHAMBER:

The lamp shown me by Sawyer and Man about October 14th, 1878, had the bottom end of the globe of the lamp ground upon a glass disk and sealed, as shown in their Patents Nos. 210,809 and 317,676 (McKeesport suit). II., 1009, **4033.**

LAMP, INCANDESCENT:

First saw an incandescent lamp in June or July, 1878, when in company with Mr. Albon Man. I went to Howard Street to see a lamp invented by Mr. Sawyer and Mr. Man. The lamp was put on the lighting circuit and illuminated. This was substantially the Exhibit Broadnax's-Sawyer-Man Lamp No. 1 (McKeesport suit). II., 990-1, **3958-63.**

I merely produce the Sawyer-Man-Broadnax Lamp No. 2 as one of a kind in which I saw the U-shaped carbons put. I did not intend to say, and don't think I did say, that I had seen the U-shaped fibrous carbon in this particular lamp. I am not willing to swear that there has never been any carbon illuminant in this lamp secured by a carbonaceous cement, because I don't know what the appearance of the lamp would be, if there had been. I am not sufficiently familiar with the appearance of the illuminant holders and the glass globe of the lamp in which illuminants have been placed to make my judgment of any value in that respect (McKeesport suit). II., 1060-1, **4239-41.**

UTILITY:

At the time I saw the Sawyer-Man lamps, in the fall of 1878, I had no knowledge as to whether they were capable of being used for practical illumination without requiring conductors of such large size as to make their use commercially prohibitive (McKeesport suit). II., 1071, **4283-4.**

VACUUM:

About October 14th, 1878, Sawyer and Man explained to me that they had used a vacuum in their lamps in place of the gas or gases described in their Patent 210,809. They explained that the vacuum answered well when they could get a good vacuum. But they had no pump that would give them a vacuum at all effectual, and they had therefore adopted an atmosphere of pure nitrogen, which they could make more or less attenuated, as practice might seem to require, to insure a satisfactory lamp (McKeesport suit). II., 1009, **4034-5.**

BULLETINS OF EDISON COMPANY.

COMMERCIAL SUCCESS:

The business of the (Edison) Isolated Company in the United States amounts thus far to 67 plants, aggregating 10,424 lamps. The business is rapidly increasing and the indications are that in the fall the energies of the Isolated Company will be taxed to fill orders (Eleventh Bulletin, of June 27, 1882). VI., 4436.

"There are 123 Edison isolated plants, aggregating 21,998 lamps, now running or in process of installation in various parts of the United States. Below is a list showing the names and addresses of the purchasers and their business." Here follows the list mentioned (Fourteenth Bulletin, of October 14, 1882). VI., 4440-2.

"Since the date of the last bulletin, October 14, we have received orders for 29 additional plants, aggregating 6,506 lamps. We have also received orders to increase five plants already installed, the aggregate increase of lamps being 328 lamps. The total number of isolated lamps up to the date of this bulletin is 153 plants, 29,192 lamps." Here follows a list of orders received since date of previous bulletin (Fifteenth Bulletin, of December 20, 1882). VI., 4443.

Since the date of the last bulletin, December 20, a list of plants in use or being installed has been received from Paris. The summary is as follows:

Country.	Installations.	Lamps.
France	32	2,680
Italy	11	5,777
Germany	28	3,667
Holland	4	1,648
Austria	7	1,724
Russia	14	2,772
Belgium	12	1,268
Total	108	19,536

(Sixteenth Bulletin, of February 2, 1883). VI., 4445-8.

"First District, New York City. This plant still runs with unvarying success. It has now been in operation seven months without stopping a moment, day or night. Not only are our customers satisfied and pay

COMMERCIAL SUCCESS—(*Continued*):

their bills, but the demand for the light bids fair to soon exceed our capacity to supply it. That fact enables us to pick our customers, and we have already begun to apply the rules of taking only those who use the light for many consecutive hours, say the greater part of all day or all night. Inquiries are frequently made for a list of customers using our light in the First District. We are at present lighting 368 houses, wired for 8,117 lamps, and a complete list can be seen at any time at our office. The following is a partial list of some of our prominent customers." Here follows the list and another giving the additional buildings which are being equipped for the light (Seventeenth Bulletin, of April 6, 1883). VI., 4448-50.

" Edison Isolated Plants—Full List. We print below a list of 334 Edison isolated plants, aggregating 65,145 incandescent lamps, now in operation in this country and in other parts of the world. The list excludes all central station plants, and embraces only isolated plants where the party using the light furnishes his own power and owns his own dynamo. It is with no little pride that we are able to state that there has never been a fire or any injury in connection with any of our plants, and second, that we have never had a single installation rejected." Here follows a complete list of of the isolated plants (Eighteenth Bulletin, of May 31, 1883). VI., 4451-9.

" First District, New York City. This plant is now in its fourteenth month of continuous running. We are at present lighting 508 houses, wired for 12,732 lamps, of which 10,164 are actually attached to the conductors, available at will. From the first the number of consumers has steadily increased, month by month, as appears by the following statement showing the number of customers and lamps at the beginning of each month since the station was first started." Here follows the statement mentioned as also another of the principal customers. " The subject of increasing the capacity of the Pearl street station is already under discussion, the demand for the light being in excess of our present facilities for supplying it" (Twentieth Bulletin, of October 31, 1883). VI., 4460-2.

" Plants sold since May 31st, 1882. The 18th bulletin contained a list of all Edison isolated plants then in operation in various parts of the world, 337 plants, aggregating 65,145 lamps. Of these 180 plants 39,519 lamps were in the United States and the remainder were in other parts of the world. Since the 18th bulletin, May 31st, 1883, we have sold the following permanent plants in the United States and Canada, making a total in this country to date of 307 plants, aggregating 59,173 lamps." Here follows a list of the additional plants referred to (Twenty-second Bulletin, of April 9, 1884). VI., 4465-8.

EDISON, AWARDS TO:

The "International Congress of Electricians," at Paris, has awarded to Mr. Edison three diplomas of honor, two gold medals and a silver medal.

EDISON, AWARDS TO—(*Continued*):

Altogether there were only eleven of the highest awards (the diploma of honor) granted, and of these only two were given to Americans, namely: one to Mr. Edison, and the other on account of the telephone. The only diploma of honor awarded for an incandescent electric light was awarded Mr. Edison.

In addition he received from the French Government the decoration of Officer of the Legion of Honor. He had been previously made Chevalier of the Legion of Honor, but the higher rank of Officer was conferred on account of his exhibit at the Paris Exposition (Fifth Bulletin, of March 17, 1882). VI., 4433.

EFFICIENCY:

The report of the Sub-Commission on Incandescent Lamps, International Exhibition of Electricity, Paris, 1881, has at last been published. The report sets forth as one of the conclusions of the commission that there is "greater economy in high resistance lamps than in low resistance." Here follows a table of the resistances of the four (Edison, Swan, Lane-Fox, and Maxim), types of lamps tested:

"The relative efficiency of the four lamps examined, expressed in carcel burners of 7.4 spermacetti candles each, produced by one horse-power of current, is as follows: (A) At 16 candles: Edison, 26.5; Swan, 24.0; Lane-Fox, 23.5, and Maxim, 20.4. (B) At 32; candles Edison, 41.5; Lane-Fox, 37.4; Swan, 35.5, and Maxim, 32.4" (Twelfth Bulletin, of July 27, 1882). VI., 4437-9.

Recently, M. M. Allard, F. Le Blanc, Joubert, Potierre, and Tresca, the French members of the experimenting commission of the jury of the Paris Exhibition, have published in the "Comptes Rendus" of the Academy the results of their tests made upon dynamos, and upon arc and incandescent lamps.

The Edison lamps tested were 528 in number, all run in one circuit from the large dynamo in the Exhibition. The Maxim lamps were tested in three groups: the first of 100, the second of 50, and the third of 25. Only 6 Lane-Fox, and 4 Swan lamps were submitted to test, the current being supplied from an Edison dynamo.

The Edison lamps gave a mean spherical intensity of 172.14 candles per horse-power when each lamp burned at 14.91 candles; the Maxim gave only 150.95 candles with each lamp at 26.6 candles; the Lane-Fox gave 130.53 candles per horse-power with each lamp at 15.58 candles, and the Swan 204.72 candles, only when each lamp was burned at 26.8 candles.

As to the efficiency of the dynamos, the Weston machine (with magnet circuits fed by a Maxim machine), consumed 23 horse-power for 100 lamps: 17.12 for 50 lamps and 9.15 for 25 lamps, while the large Edison dynamo, when running 528 lamps, consumed 68.74 horse-power. In the first case, 56 per cent. of the power appeared in the lamps: in the second case, 56 per cent., and in the third case 61 per cent., while with the Edison dynamos, 67 per. cent. of the energy appeared as work in the lamps. (Twentieth Bulletin, of October 31, 1883), VI., 4463-5.

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BULLETINS OF EDISON COMPANY.

INFRINGEMENT:

In regard to the reasons why the Edison Company joined the Gramme combination: "One of these arguments, namely, uniformity of prices, had little influence with us. We were and are engaged exclusively in incandescent lighting, of which we have a monopoly, whereas all the other companies are engaged in arc lighting wherein the competition is fierce, and they all suffer from the cutting of prices. Still, aside from this question of prices, the other arguments had weight with our committee, and in February this year they reported to our company in favor of our joining the combination. * * * From the above statement of facts it will be seen that we have in no sense whatever surrendered our individuality, parted with any of our rights, or even in the slightest degree altered our established position as sole inventors and exclusive proprietors of a system of incandescent lighting" (Ninth Bulletin, of May 15, 1882). VI., 4435-6.

"Edison's suit against the Maxim lamp for infringement, Paris. The suit brought at Paris, France, by the Edison Company against Hiram S. Maxim for infringing Edison's incandescent light patents has been noted for trial, and we are instructed that the trial will take place in November." "Edison's suit against the Swan lamp for infringement, London. A patent suit has been commenced in London by the Edison Company against the Swan Company on the ground that the Swan lamp infringes the Edison. The fundamental principles of incandescent lamps are at issue in the suit" (Thirteenth Bulletin, of August 28, 1882). VI., 4439.

"The Edison suit against the Swan lamp for infringement, London. The patent suit mentioned in the Thirteenth Bulletin as having been commenced in London against the Swan lamp is being pressed as rapidly as possible by the Edison Company. The fundamental principles of incandescent lighting are at issue in the suit. Thus far the matter has been brought before the English Court on two minor points, both of which were decided in favor of the Edison Company. The first was on the question of compelling the Swan Company to keep an account of their manufacture of lamps pending the trial so as to afford the Edison Company a correct basis for fixing damages; and the second was on a question between the two companies touching the services of eminent counsel claimed by both companies. On both these preliminary issues the decision of the Court was in favor of Mr. Edison. The Edison Company in London is devoting itself with great energy to preparing for the trial, and every effort will be made to have it take place as soon as the case is reached on the docket of the Court, probably this spring (Sixteenth Bulletin, of February 2, 1883). VI., 4444-5.

BURNS, Hugh A.

is a carpenter. Was employed by Wallace & Sons from 1868, or 1869, to 1887. Went into their carbon department in 1878, and continued in that department until 1887.

CARBON:

In making the carbons at Wallace's, at Ansonia, in 1879, pulverized carbon was mixed with carbonaceous liquid, then forced through nozzles (from 1-64 to 1-16 of an inch in diameter), of the desired shape and size; these rods were then packed in crucibles or vessels, placed on the fire and baked. In 1879 we had many different mixtures, but in 1884 we had definitely adopted coke and tar. The carbons made in 1878 and 1879 were soaked in a carbonaceous liquid and rebaked. II., 1197-8, 1200 and 1203, **4788-4812.**

CROSS-SECTION:

In 1879 we made, at Ansonia, carbons called "millimeter" carbons, which had a diameter of 31⅓ thousandths of an inch, and a length of 9 or 10 inches. II., 1198, **4791-2.**

The smallest sizes of burners disclosed by my note-book of 1879 are 1-16, 1-8 and 3-16 of an inch. II., 1201, **4801.**

CHANDLER, Prof. Charles F.:

DISCOVERY:

In a paper "On the Present State of Electric Lighting," read before the British Association for the Advancement of Science, August 20, 1878, Mr. Shoolbred says: "Though electricity may replace gas lighting to some extent in the illumination of large areas and in certain manufactures, yet it cannot pretend to trench upon the special and the most extensive field for the use of gas, the lighting of private houses, until some permanent, indestructible light, producing points very different from the present carbon sticks (arc lights), be discovered" (Trenton "feeder" suit). VII., 5143, **12571.**

DISTRIBUTION OF ELECTRICITY:

"The successful use of the (Edison) incandescent lamp involves the necessity of controlling the current at the central station by means of a properly constructed circuit, where the management of the lamp (that is, the regulation of the current operating it) is entirely beyond the control of the person using it" (Trenton "feeder" suit). VII., 5123, **12490.**

"The invention of this (Edison's) lamp did not solve the difficulties in the way of the distribution of electricity over large areas. On the contrary, it increased them because this lamp is an extremely delicate device for producing light by the action of electricity." It requires a current of uniform pressure, the extreme variation in which should not exceed five per cent. or even two per cent., and this uniformity must be maintained over large areas, irrespective of the number of lamps in use. No system which would accomplish this result was known at the time of application for Edison's lamp patents Nos. 223,898 and 230,255 (Trenton "feeder" suit). VII., 5166-7, **12662-5.**

DURABILITY:

When the current is properly adjusted the (Edison) lamp is a constant, uniform and durable means of developing light (Trenton "feeder" suit). VII., 5122, **12488.**

The carbon burner of a modern lamp can be destroyed in a very few minutes by using a current not adapted to it, but not so soon as a platinum burner, because the former is infusible. Practically, a modern lamp should have a properly regulated current. VII., 5012, **12046-8.**

EDISON'S LAMP:

I am familiar with Edison's lamp referred to in Patent No. 264,642 (Edison's patent for a "feeder" system of electrical distribution). This lamp con-

EDISON'S LAMP—(*Continued*):

sists of a very delicate filament of carbon which is usually in the form of a loop, the ends of which are attached to wires. The loop is enclosed in a glass globe from which the air is exhausted, the two wires passing hermetically through the glass. When the current is properly adjusted, this lamp is a constant, uniform and durable means for developing light (Trenton "feeder" suit). VII., 5121-2. **12484-8.**

I have no experimental knowledge of the lamps of De Moleyns, De Changy, Starr and King, Greener and Staite, Lodyguine, Kosloff, Konn, Woodward, Werdermann, Sawyer and Man, and of Edison's platinum lamp. I have seen a Werdermann lamp, but never experimented with one. My knowledge of these early lamps is based upon what I have read and not upon any exact experiments that I remember any one to have published. I have had three Lane-Fox platinum lamps, but they were obtained several years later than 1880, and I do not know whether they were made before that date or not. I suppose from what I have read of Lane-Fox's platinum lamps that they might be made available for use to some extent with proper means for regulating the current supplied to them, but my own experience gave me no basis for an opinion, as the lamps which I had were destroyed as soon as I turned on the current. The carbon burner of a modern lamp can be destroyed in a very few minutes by using a current not adapted to it, but not as soon as a platinum burner, because the former is infusible. Practically, a modern lamp should have a properly regulated current. VII., 5011-2. **12041-8.**

FEEDER SYSTEM PATENT:

Note. This is Edison's U. S. Patent No. 264,642, applied for August 9, 1880, and dated September 19, 1882, for "Electric Distribution and Translation System,"—the patent in litigation in the Trenton "feeder" suit.

Each claim of this patent involves four elements:

First. Incandescent lamps grouped in large numbers into one system and arranged in multiple arc in an all-round metallic circuit, and uncontrolled from the central station as to the number in use by the consumers.

Second. A central station for supplying and regulating the current.

Third. A set of conductors with which no translating devices of any kind are connected, and whose function is to carry the current, and to meet the difficulty involved in carrying it to a distance without exceeding practical limits in the size, weight and cost of metal. This involves the localization or concentration in the feeders of all drop in tension beyond a negligible amount (and such an excess of drop must exist somewhere in a system involving large numbers of lamps, large areas and reasonable economy in conductors).

Fourth. A consumption or service circuit which is so proportioned or limited in reference to the number and location of the lamps connected

FEEDER SYSTEM PATENT—(*Continued*):

with it that there is no essential drop in tension between the lamps nearest to the source of electricity and those most remote from it (Trenton "feeder" suit). VII., 5171. **12682-4.**

The system described in this patent was the first system invented which made domestic electric lighting possible, because it produced means by which electricity could be distributed or divided over a considerable area without incurring prohibitory expense for conductors; and because it permitted the use of simple, unregulated lamps on large systems, which could be supplied with current at a constant pressure by regulation at the central station irrespective of the number of lamps in use (Trenton "feeder" suit). VII., 5173. **12690.**

KING'S LAMP:

In 1881 Mr. Swan read a paper in which he said: "It is forty years since Starr, through his agent, King, took out his patent for producing light on this (incandescent) principle. It is only within the last two or three years that the many practical difficulties that beset the utilization of this method have been surmounted. Nothing can well be simpler than the ideal incandescent lamp—a slip of carbon in a vacuum, that is all. To realize this idea much experimentation had to be gone through and much disappointment to be suffered" (Trenton "feeder" suit). VII., 5147-8. **12588-9.**

LAMP, INCANDESCENT:

I have never seen any of the lamps made before Edison's carbon filament lamp excepting that of Werdermann (Trenton "feeder" suit). VII., 5200. **12799.**

The Werdermann lamp is an incandescent arc (semi-incandescent) lamp. VII., 5012. **12048.**

QUALIFICATION OF WITNESS IN RESPECT TO LAMPS:

I have no experimental knowledge of the lamps of De Moleyns, De Changy, Starr and King, Greener and Staite, Lodyguine, Kosloff, Konn, Woodward, Werdermann, Sawyer and Man, and of Edison's platinum lamp. I have seen a Werdermann lamp, but never experimented with one. My knowledge of these early lamps is based upon what I have read and not upon any exact experiments that I remember any one to have published. I have had three Lane-Fox platinum lamps, but they were obtained several years later than 1880, and I do not know whether they were made before that date or not. I suppose from what I have read of Lane-Fox's platinum lamps that they might be made available for use to some extent with proper means for regulating the current supplied to them, but my own experience gave me no basis for an opinion, as the lamps which I had were destroyed as soon as I turned on the current. The carbon burner of a modern lamp can be destroyed in a very few minutes by using a current not adapted to it, but not as soon as a platinum burner, because the former is infusible. Practically, a modern lamp should have a properly regulated current. VII., 5011-2. **12041-8.**

RESISTANCE:

The lamps with carbon burners made before Edison's filament lamp had carbon rods and would have been of too low a resistance for successful use in multiple arc (Trenton "feeder" suit). VII., 5200, **12797.**

SUBDIVISION:

There was no method known in and prior to 1880 by which large numbers of electric lamps, of a power about equal to a gas burner, could be practically operated over large areas. The problem necessary to be solved, in order to render electric lighting with lamps of low candle-power and in large numbers, feasible and practicable, was to devise a system of distribution by which the current necessary to operate the lamps could be economically sent great distances to all parts of the district, and be supplied under proper regulation to the lamps irrespective of the number in use and whether far from or near to the source of electricity. In accomplishing this result the lamps must be individually under the control of the user, and this without affecting the current supplying other lamps; also the conductors must be of a sufficiently moderate size to bring their cost within commercial limits. Prior to 1880 this problem was regarded as extremely difficult, if not impossible, of solution (Trenton "feeder" suit). VII., 5123 5, **12492-7.**

In testifying before the Parliamentary Committee in 1879, Mr. Conrad W. Cooke agrees with Dr. Siemens that centralization rather than distribution should be the method adopted in electric lighting, and says subdivision "is the insuperable difficulty at present as regards domestic illumination." He also mentions "parallel (multiple) arc," and with reference thereto says: "When you attempt to subdivide the light between two or three the intensity diminishes in a marvelous ratio." He is unquestionably in favor of the series in preference to the parallel method of subdivision. (VII., 5218, **12510-11.**)

Mr. Preece, electrician to the Post-office, says that the result of his mathematical investigations show "that, when lamps are joined up in series, the intensity of the light in each lamp diminishes with the square of the number inserted; and, when they are joined up in this parallel arc, the intensity of the light diminishes as the cubes of the number, showing that when you attempt to subdivide the light beyond two or three the intensity diminishes in a marvelous ratio." (VII., 5131, **12523.**)

Mr. Deacon says: "I think that up to five or six lights on one circuit there is a possibility of division in series being accomplished with moderate economy; and it may be that division in multiple arc will also be carried to somewhere about the same extent. But beyond that I think either of them will be so costly as to put a stop to much further division on any system which has yet been tried. (VII., 5132, **12528.**) * * * I think it is quite possible that it (the electric light) will be applied (to domestic lighting) as a luxury; but, so far as I can see at

SUBDIVISION—(*Continued*):

present, again in the light of experience up to the present date, I do not think it is likely to be applied economically." (VII., 5133, **12531.**)

William Trant, in "Nature" (for November 21, 1878), discusses the divisibility of the electric light, and says: "It will be seen, then, from what has been above stated, that the production and divisibility of the light by incandescence is a very wasteful process; so wasteful, indeed, as to render its practical application impossible for general lighting." (VII., 5141, **12561.**)

In an interview published in the "New York Times" for December 28, 1879, Prof. Morton is reported to have said: "The next difficulty is in the economical production of lights by electricity. This is what is commonly meant by the phrase 'Dividing the electric light.' Up to the present time, and including Mr. Edison's latest experiments, it appears that this involves an immense loss of efficiency." In his lecture before the Gas Light Association (published in the "American Gaslight Journal" of January 2 to February 17, 1879), Dr. Morton, in speaking of the Werdermann lamp, says: "It will be noticed that here, as with all other lamps working by incandescence, there is a great loss, which increases with the subdivision." (VII., 5142, **12566-8.**)

In a paper "On the Present State of Electric Lighting," read before the British Association for the Advancement of Science, August 20, 1878, Mr. Shoolbred says: "Though electricity may replace gas lighting to some extent in the illumination of large areas and in certain manufactures, yet it cannot pretend to trench upon the special and the most extensive field for the use of gas, the lighting of private houses, until some permanent, indestructible light producing points very different from the present carbon sticks (arc lights) be discovered." (VII., 5143 **12571.**)

In a paper on "The Absolute Economy of Electric Lighting," published in "Engineering" and copied into the Journal of the Franklin Institute for Sept., 1880, Mr. Briggs says: "The problem of electric lighting to-day is the production of small enough quantity of light with equal economy to that attained for large illuminating effects, and of the distribution into small sources of light of the great light capacity now obtained at a single point of emission. To these ends the intelligence of all electricians is now directed, and the attainment of some measure of success can be confidently anticipated." (VII., 5143, **12572.**)

Mr. Preece published an article on the electric light in "The London, Edinburgh and Dublin Philosophical Magazine" for January, 1879, in which he demonstated the hopelessness of the extensive division of the electric current for illuminating purposes. His article closes as follows: "It is this partial success in multiplying the light that has led so many sanguine experimenters to anticipate the ultimate possibility of its extensive subdivision: a possibility which this demonstration shows to be hopeless, and which experiment has proved to be fallacious." (VII., 5144, **12573-4.**)

[Note. It should be borne in mind that in the original article, from which the above is quoted, there is an asterisk over the word

SUBDIVISION—(*Continued*):

"fallacious," which refers to a foot-note calling attention to Chapter XI. of Fontaine's work on "Electric Lighting." This chapter of Fontaine's work contains an account of the author's efforts to accomplish subdivision with the Konn incandescent carbon lamp (Preece's complete article is contained in Vol. VI., pp. 4084-90).].

Mr. Swan read a paper on "Electric Lighting by Incandescence" before the British Association for the Advancement of Science in 1881, in which he says: "But the crowning merit of electric light produced on the principle of incandescence is that it is indefinitely divisible without sacrifice of economy. • • • This property of divisibility into as many small centres of illumination as are required —which is inherent to this method of electric lighting by incandescence to fully the same extent as in gas light—combined with the steadiness of this species of light, its good color, and its wholesomeness, gives it a character of general applicability which is not possessed by any other kind of electric light. It is forty years since Starr, through his agent, King, took out his patent for producing light on this principle. It is only within the last two years that the many practical difficulties that beset the utilization of this method have been surmounted. Nothing can well be simpler than the ideal incandescent lamp—a slip of carbon in a vacuum, that is all. To realize this idea much experimentation had to be gone through, and much disappointment had to be suffered. • • • Now that we can look to the method of electric lighting by incandescence as a perfectly practicable method, and now that we have the means of combining the economy of the mechanical generation of electricity with the constancy and many conveniences of voltaic accumulation, it is clear that the time is now ripe for the almost unlimited application of electric light to general purposes, and that engineers may, with much advantage, give their immediate attention to the many details which fall within their province in connection with the mechanical production and distribution of electricity on a large scale." (VII., 5147-8, **12587-91.**)

In a paper on "The Edison System of Electric Distribution," published in "The Electrician" for September 9, 1882, F. J. Sprague, Ensign U. S. Navy, says: "At Holborn Viaduct there are, as many of you know, about 1,100 to 1,150 (Edison) lamps furnished from the central station, distributed over a space extending from Holborn Circus to the Post-office. The system of distribution here is that of multiple arc and branch circuits. Evidently, while simple circuits give perfectly satisfactory results in buildings and on the streets for short distances, they will not do for large districts. And it is this question of distribution over large areas to which Mr. Edison has given a great deal of thought, and has, I think, satisfactorily solved the problem." (VII., 5150, **12598-9.**)

An article on "General Incandescent Electric Lighting in New York" was published in the "Scientific American" for September 16, 1882. It states that, "when Mr. Edison first attacked the problem of incandescent electric lighting, he was met with the general objection of electrical authorities that a durable incandescent lamp could not be made. When he proposed to subdivide the electric current, so as to multiply small lamps economically, he was warned on all sides that he was in pursuit of an impossibility; the thing could not be done. Having produced the desired lamp and subdivided the current experimentally, his critics not less confidently asserted that a laboratory experiment was one thing, the practical application of a theory to a complex system of public service was quite another, and he was bound to fail. It was a question of economy; and, admitting that an incandescent electric lighting system could be furnished under the conditions required, it would not pay." (VII., 5151, **12602-3.**)

SUBDIVISION—(*Continued*):

The witness concludes from these quotations and others given in his answer that, prior to 1880, it was regarded as extremely difficult, if not impossible, to devise a system of electrical distribution which would render electric lighting with lamps of low candle-power, distributed over wide areas and in large numbers, feasible and practical. (VII., 5161, **12643**), (Trenton "feeder" suit). VII., 5128-61, **12510-643.**

In the working of small electric light plants involving the use of a small number of lamps operated at short distances, there would be no difficulties to overcome such as would be met with in attempting to operate a large number of lamps distributed over large areas, and which it is the object of Patent No. 264,642 (Edison's "feeder" patent) to remedy. With a limited number of lamps distributed over small areas, there would be no difficulty in providing conductors at a reasonable cost which would supply the current to all the lamps without involving such a variation in pressure as would interfere with the durability and usefulness of the lamps. In establishing such plants no knowledge or experience would be gained with regard to the necessity of providing distribution for large numbers of lamps distributed over large areas (Trenton "feeder" suit). VII., 5175, **12698-9.**

Prior to 1880, the term "subdivision of the electric light" was used to express the idea of a number of small electric lights of moderate illuminating power in place of one or any small number of electric lights of great illuminating power. At that time not many, if any, persons realized all that was necessary in order to accomplish this result. That is, they did not realize all the conditions which have since been found necessary in order that a large number of small lamps, distributed over large areas, might be practically operated from one central station. In fact, most of them thought it impossible to solve this problem. This problem, commonly referred to prior to 1880 as the "subdivision of the electric light," included a proper distribution of the current, selecting a proper kind of current, and the proper devices for converting electrical currents into the desired kind of light, and doing this in a manner sufficiently economical to make it commercially practicable; also the accomplishing of this over comparatively large areas. It was not until the system of Mr. Edison (described in Patent No. 264,642) came to be understood after the year 1880, that electricians realized that subdivision, in the broad sense just

indicated, had been solved (Trenton "feeder" suit). VII., 5176-7, **12703-7.**

I think there were several incandescent lamps known at the date of the report of the English Parliamentary Commission, June 13th, 1879, which would be practically useful lamps for commercial illumination, and suitable for use with Edison's "feeder" system of distribution: "I think the Konn, the Woodward and the Sawyer and Man, and possibly two or three others that I mentioned, could have been practically used. They would, of course, be very poor affairs compared with the lamps of to-day, and with their use electric lighting would not have been as economical as it is now. Perhaps fewer customers would have introduced the light had it been offered; but, without considering the commercial question, which depends upon a great many conditions, I think some at least, if not all, of these lamps could have been practically used. They were not used practically for the reason that with the successful invention of the feeder system came a number of new lamps which were so much better than the old ones that, when practical electric lighting was adopted, the improved lamps were employed. It is impossible to say at this time to what degree practical electric lighting would have become successful, after the invention of the patent in suit ("feeder" system of distribution, Patent No. 264,642), had no improvements been made in incandescent lamps. * * * At or about the time this patent was taken out, so many other inventions or improvements were made, all of which contributed more or less to the practical solution of the problem, that, when the first practical attempts to provide electric lighting by means of a large number of lamps distributed over a considerable area was made, neither the old lamps nor the old dynamos were employed. * * * I think he (Mr. Edison) invented a complete system of incandescent electric lighting, including all the essential elements necessary for practical commercial success" (Trenton "feeder" suit). VII., 5180-2, **12719-26.**

In testifying before the Parliamentary Committee, in 1879, Mr. Cooke had in mind the loss, which he attributes to the substitution of several small arc lights for one large arc light; again he refers to this loss with incandescent lamps, and, at another place, is perhaps comparing the loss with incandescent lighting as compared with the result which would be obtained with a single arc light. "He speaks of divided currents, and a loss resulting from such division, as expensive and uneconomical as compared to the system in which one machine is used for each light. * * * I must say, after carefully looking through Mr. Cooke's testimony again, that I do not find any distinct reference to a loss from subdivision due to the resistance of the conductors (Trenton "feeder" suit). VII., 5183-4, **12732-6.**

Mr. Preece, in testifying before the Parliamentary Committee in 1879, refers to his own paper on subdivision, which had been previously published in the "Philosophical Magazine," and states that, in writing said paper, he had

in mind the loss of light which takes place when the current is divided among several lamps, as compared with the light obtained when the whole current is supplied to a single lamp, this being the sense in which Mr. Cooke considered the question of subdivision. Mr. Preece's paper in the "Philosophical Magazine" purports to be a mathematical demonstration which proves that, when the lamps are connected in series, the intensity of the light in each lamp diminishes as the square of the number of lamps, and when joined up in multiple arc, as the cube of the number. In this paper reference is made to Chapter XI. of Fontaine's book on "Electric Lighting" as an authority for the statement which Preece makes, that experiment has proved the ultimate possibility of extensive subdivision to be fallacious. Fontaine's experiments substantiates the statements made by Preece. The fallacy underlying Fontaine's experiments and Preece's computations was that they assumed that the smaller lights were to be obtained without change in the construction of existing lamps, by delivering a smaller current to each lamp, thus reducing the temperature of the burner at each lamp, and the amount of light emitted by it. The enormous loss of energy by the method of subdivision, which they assumed, was due to the fact that the heat developed in the burner decreases in a much greater ratio than the decrease in the current; and the light produced, in turn, decreases much more rapidly than the heat. This fallacy was very prevalent among the electricians who discussed electric lighting prior to 1880, and quite a number of the witnesses who testified before the Parliamentary Committee seemed to have the same idea. Among scientific men, Preece, Cooke, Siemens and Traut adopted this fallacy and upon it based their opinion as to the possibility of subdivision. Prof. Morton, in his lecture before the "American Gas Light Association" in 1878, seems to accept the fallacy in the early part of the lecture, but, in closing, evidently doubts its truth (Trenton "feeder" suit). VII., 5184-7, **12736-46** and 5195-6, **17778-81.**

An electric lamp, having an illuminating power about equal to a gas jet and adapted to the same purposes, which possessed such characteristics as would make it practicable for one generator to operate a considerable number of such lamps, located at reasonable distances from it, and which at the same time was economical, durable and cheap enough to make it commercially useful, and so simple and reliable that it could be manipulated by the public, would, prior to 1880, have undoubtedly have been recognized as one of the necessary elements of the problem of subdivision as the problem was then understood, but it was recognized that the problem required, as an equally essential element, a system of distribution which would economically supply the lamps in use at any one time with a current of such a character as to pressure and uniformity as would properly actuate the lamps. Lamps had been invented which possessed many if not all the characteristics of the hypothetical lamp just referred to, but they had not been carefully tested over any considerable area with a proper system of distribution. Without considering Edison's carbon filament lamp, other lamps like those of King, Konn, Sawyer and Man,

SUBDIVISION—(*Continued*):

Woodward, Edison's platinum lamp, or even Werdermann's lamp of 1878, or the Lane-Fox lamp of 1878, might have been found successful if the other elements of the problem had been worked out, assuming that no better lamps were brought in competition with them. All the carbon lamps to which I have referred had carbon rod burners and would have been of too low a resistance for successful use in multiple arc. Had they been put into practical use, however, their resistance could have been increased by reducing the size of the carbon. How far this modification could have been carried without invention I do not know. I have never seen any of the lamps made before Edison's carbon filament lamp, excepting that of Werdermann, and do not know whether the resistance of these lamps could have been increased so as to adapt them for commercial use with the "feeder" system of distribution without invention. My only doubt is as to whether such a reduction in the size of the carbon rod as would be necessary for the "feeder" system of distribution would or would not so modify the lamp as to lead the Courts to decide that it embodied a new invention (Trenton "feeder" suit). VII., 5197-201, **12788-801.**

Edison's carbon filament lamp only in part solved the problem of subdivision. He invented a complete system of domestic electric lighting for large areas. His system includes the improved dynamo, a distributory circuit, a lamp, a meter, pressure wires, regulating device for the dynamo, safety plugs, junction boxes, etc. I do not think the lamp alone solved the problem of subdividing the electric light. I think the system of distribution was essential to the so-called solution of the problem. I regard the Edison carbon filament lamp as one of the most important inventions that has ever been made in electric lighting, but I am not prepared to admit that it constituted the principal part of the practical solution of the problem of subdivision. I think the problem was solved by the "feeder" system of distribution in connection with the lamps previously known and would have been solved with lamps known prior to November, 1879, and that the system was the most essential element. It is my opinion that domestic lighting from a single source with a considerable number of lamps distributed over a considerable area, and comparable in illuminating power to ordinary gas jets, could have been successfully introduced by means of the "feeder" system with the lamps and other apparatus known before November, 1879 (Trenton "feeder" suit). VII., 5201-3, **12804-9.**

In saying, in answer to 7 Q., that, prior to 1880, the problem necessary to be solved in order to render electric lighting with lamps of low candle-power and in large numbers feasible and practicable, was to devise a system of distribution by which the current necessary to operate the lamps could be economically sent great distances, etc., etc., I had in mind a number of lamps and their distance from the source approximately comparable to the number of gas jets supplied from a single gas works, and their dis-

SUBDIVISION—(*Continued*):

tance from the same, though I think a gas works may be made to supply a larger area and a larger number of lamps economically than a single central electric light station (Trenton "feeder" suit). VII., 5203, **12811-2.**

The witnesses before the Parliamentary Committee in 1879, who testified concerning the number of lights to which subdivision was then limited, mention six lamps, not as a limit to the requirements of the problem, but as a limit to what they believe to be the possibility of its solution. They thought six lamps might be run with success from a single dynamo; they did not think that this was the largest number that it was desirable to run. The whole point of the discussion was the problem of replacing gas lighting for domestic purposes by electric lighting. The system of electric lighting by small numbers of arc lamps or Jablochkoff candles of very high illuminating power had already been perfected, and the remaining problem of "dividing the electric light," embodied such a modification of the system as would substitute for the few lamps of high illuminating power many lamps of low illuminating power (Trenton "feeder" suit). VII., 5204-5, **12815-7.**

Prior to November, 1879, it would have been regarded as a great step in advance towards a satisfactory solution of the problem of subdividing the electric light, if quite a small number of lamps, each about equal to a gas jet, and having the requisite durability, simplicity and cheapness, could have been run by one generator with reasonable economy when distributed over a limited area, as, for instance, if such a number of lights, each of a power equal to a gas jet, as would be required to light an ordinary sized building or factory, say 50 or 100 lights, located throughout such building, could be supplied from a dynamo located in the basement or L of such building (Trenton "feeder" suit). VII., 5204-5, **12818-20.**

The difficulty due to the large variations in pressure which follows from attempting to supply a large number of lamps over large areas, and which interferes with their durability and usefulness, would not have been met with in small plants, either before or after the date of application for the "feeder" patent (August 9, 1880). No difficulty would have been experienced by a skilled electrician, prior to that date, in making conductors large enough to secure an evenness of pressure throughout all parts of a multiple arc system of distribution of any size, up to the point where the difficulty due to the cost of the conductors required for supplying an increased number of lights over larger areas, begun to manifest itself. Up to this point the electrician would have naturally met the difficulty (Trenton "feeder" suit). VII., 5208-9, **12831-4.**

Prior to June, 1880, a skilled person would have known how to take the arrangement of circuits shown in Khotinsky's French Patent and pro-

12

CHANDLER, Prof. Charles F.

SUBDIVISION—(*Continued*):

portion the conductors so that equality of pressure would be obtained with a plant of fifty or one hundred lamps located in the same building or in its immediate neighborhood, the lamps being like those mentioned in Lane-Fox's Patents Nos. 3988 and 4626 of 1878, and in Edison's Platinum Lamp Patent No. 227,229, and Carbon Filament Patent No. 223,898 (Trenton "feeder" suit). VII., 5209-10. **12836-9.**

UTILITY:

In a paper read in 1881, Mr. Swan said: "It is forty years since Starr, through his agent King, took out his patent for producing light on this (incandescent) principle. It is only within the last two or three years that the many practical difficulties that beset the utilization of this method have been surmounted. Nothing can well be simpler than the ideal incandescent lamp—a slip of carbon in a vacuum, that is all. To realize this idea much experimentation had to be gone through and much disappointment to be suffered" (Trenton "feeder" suit). VII., 5147-8. **12588-9.**

The lamps of Konn, Woodward, and of Sawyer and Man, would be very poor affairs compared with the lamps of to-day (Trenton "feeder" suit). VII., 5180. **12719.**

I regard Edison's carbon filament lamp as one of the most important inventions that has been made in electric lighting (Trenton "feeder" suit). VII., 5202, **12807.**

Edison's platinum lamp and Lane-Fox's lamp, having a burner made of a long length of platinum and iridium wire could have been used commercially with the "feeder" system of distribution had no better lamps been produced (Trenton "feeder" suit). VII., 5206-7, **12824-5.**

CLARKE, Chas. L.

AIR WASHING:

Air washing is the mechanical action of the gas in the lamp chamber moving over the surface of the burner and tending to wear it away. V., 3827.

ART, HISTORY OF:

The literature of the subject shows that subdivision was attempted by means of incandescent lamps many years prior to 1879. V., 3552.

No statement of any kind is made prior to the patent in suit concerning carbonized thread or filament burners. V., 3786.

BURNER OF CARBON:

Burners of carbon in prior lamps were enclosed in separable lamp chambers. V., 3587-8.

Prior to patent in suit carbon burners, even when made quite thick, were supposed to be limited to a life of few hours, and there was no information extant as to the specific resistance and physical properties of carbon in a high vacuum, which made it possible to determine mathematically the size to be given to a carbon burner to ensure for it the same extent of use as Edison's platinum burner. V., 3590.

Lodyguine was not, as Wild states, the first to suggest the use of carbon in place of platinum as a material from which to make an incandescent burner. V., 3598.

Wild was wholly without appreciation of the function performed by the radiating surface of a burner. His statement that a carbon rod fifteen times thicker than a platinum wire will, with the same current, engender the same amount of heat, is correct, but an amount of heat sufficient to make a platinum wire incandescent would not raise the carbon rod to a temperature at which it would give out any light. V., 3599.

Prior lamps had large burners requiring great amount of current to bring them to incandescence as compared with filamentary burners of modern lamps, requiring only moderate current. V., 3614.

The length, diameter, and surface of the burner must be taken into consideration in subdivision. V., 3625.

When, for commercial reasons, we divide a single burner into several burners of less illuminating power, we should increase the resistance and diminish

BURNER OF CARBON—(*Continued*):

the surface of the lesser burners, in order not to increase the size and cost of the conductors. V., 3626.

After making a lamp according to instructions of patent in suit, and measuring its candle-power and the electro-motive force and current required to operate it, a skilled person would have known what dimensions to give to another burner to get any desired candle-power and requiring a given electro-motive force and current. V., 3626.

At the date of the patent in suit the theoretical knowledge of electricity extant was sufficient to enable a person to properly proportion a burner to give a desired amount of illumination, but, in the absence of a practical incandescent lamp, such ability would hardly have been called into play, or, if it were, it would not have accomplished anything toward subdivision. V., 3627.

Having been furnished by the patent in suit with the knowledge that the seemingly fragile burner was durable, persons skilled in the art would have been in possession of a practical incandescent lamp, and would have known what changes to make in the burner to obtain lamps of any desired illuminating power. V., 3633.

Burners as to-day made are more durable than formerly, and can be operated at a higher temperature and incandescence, thus making the lamps more economical. V., 3640.

Increase of resistance in the burner of a modern lamp during its use is, in the main, considered to be due to diminution in the mass of the carbon. V., 3660.

The disintegration of the carbon of the burner of a modern lamp, resulting in blackening of the globe, is not sufficient to impair the commercial durability of the burner. V., 3663.

Greener & Staite taught in their patent of 1846 that the carbon burner was to be made more durable *solely* by increasing the purity of the carbon. V., 3676.

Edison's invention, so far as it was the outcome of any discovery, was based upon the discovery that a carbon burner, even when small in diameter and of high specific resistance, would be practically stable, when enclosed in a globe from which all gases had been permanently removed. V., 3683.

At the date of the patent in suit no one would have supposed that substituting carbon burners of small diameter, like those of the patent in suit, in place of the carbon rods of old lamps, and enclosing them in lamp chambers

BURNER OF CARBON—(*Continued*):

having a high vacuum, would have rendered the burners durable. V., 3685.

The carbon pencils of the old lamps were large enough and sufficiently strong to withstand mechanical shocks, but Mr. Edison showed how evaporation could be prevented, and gave the art the means of making both large and small carbons available for a practical lamp. V., 3689.

The burner of the modern incandescent lamp has mechanical stability, and can withstand the effects of the current and heat. They do not break on account of evaporation. V., 3691.

Du Moncel was of opinion in 1880 that the heat of the current would destroy the small, slender carbon of the Edison burner. V., 3693.

Since the date of the patent in suit the efforts of the art have been directed to the obtaining, and have obtained, carbon burners of exceedingly small cross-section. V., 3714.

The large carbon burner (*e. g.*, the 100 candle-power Edison) will admit of lower vacuum than the smaller 16 candle-power, for the low vacuum conducts away the heat more rapidly, rendering larger current necessary to keep the burner up to proper temperature and candle-power. Under these conditions the larger burner appears to have more mechanical stability to withstand the increased current and heat than the smaller burner. V., 3721.

Since the date of the patent in suit "burner" and "filament" are used in the art as synonymous terms. V., 3738.

Whether a burner is to be considered as "large" or "small," depends upon its size, and not upon whether it can be used in multiple arc or series. V., 3744.

Burners in the Edison lamps of 100 candle-power are about the same size; *i. e.*, cross-section, as the 15 candle-power Municipal lamp burner, but the 100-candle power burner is nearly eight times as long as the 15 candle-power Municipal lamp burner. V., 3757.

The result of the process described in the patent in suit is a carbon burner of high specific resistance. V., 3767.

A carbon burner has high specific resistance when its resistance is high compared with what it would be if it were made of dense gas, or unplated arc light carbon. V., 3768-9.

The term "pencils" as used in Sawyer-Man patents means the same as "rods," and there is no indication that any other form of burner was contemplated. V. 3781.

BURNER OF CARBON—(*Continued*):

Burners larger than those of filamentary form can be made by the process described in the patent in suit. V., 3805.

Patent in suit does not contain the earliest description of a process which might be employed in making carbon burners, whereby they can be produced of such size and resistance as to adapt them for use in multiple arc. One such process was known, but no burners having been made under this method suitable in size and resistance for use in multiple arc, and there being other unsuitable processes in existence, it was important that the patent should ascertain and announce the practicable process. V., 3087-9.

A carbon burner in a high vacuum, in an all-glass globe, is described for the first time in the patent in suit. V., 3815.

In June, 1879, after the issue of Edison's French patent for platinum lamp, no one, in view of the state of the art, would have been led naturally to consider the question of substituting a carbon burner in place of the platinum burner, or of making such a carbon of high total resistance. V., 3818.

Gaudoin's process was suitable for making carbons to be used in multiple arc, and was known prior to the date of patent in suit. This process contemplates the reduction of suitably selected wood to the definite form the carbon is to have, and its subsequent carbonization. V., 3831.

The burner attributed to Dr. Adams would be classed as a rod, as it has an area considerably larger than that of the Thomson-Houston rod burners referred to, and nearly as large as the largest series burner made by that company. V., 3855.

CANDLE-POWER:

Practical experiment in gas lighting has shown that the 16 candle-power light is best suited to lighting ordinary interiors. V., 3621.

If 100 candle-power lamps had been made after the manner described in the patent in suit, the art, without further instruction, would have known how to construct similar lamps, each having a power equal to a gas-jet, which could be supplied from a single source of electricity. V., 3623.

After making a lamp according to instructions of patent in suit, and measuring its candle-power and the electro-motive force and current required to operate it, a skilled person would have known what dimensions to give to another burner to get any desired candle-power and requiring a given electro-motive force and current. V., 3626.

Knowing that the seemingly fragile burner of Edison's lamp was durable, persons skilled in the art would have known how to change the burner, so as to get lamps of any required illuminating power. V., 3633.

CANDLE POWER—(*Continued*):

If run at much higher than normal incandescence, the life of the lamps would be too short; while if run at much lower than normal incandescence, their economy would be too low for commercial purposes. V., 3643.

Lamps are designated as 16 candle-power or 100 candle-power, because the manufacturer intends them to be operated under conditions which will cause them to produce this amount of light at the best economy. It will take 6¼ times as much power to operate an incandescent lamp of 100 candle-power as to operate one of 16 candle-power, providing that both are operated at their normal incandescence. Above or below this normal incandescence there is loss of economy in operating the lamps. V., 3643.

The tests of Foussat and Siemens do not prove that it is economical to run lamps above or below their normal candle-power. V., 3644-7.

The illuminating power increases in a very much more rapid ratio than the increase in the heat developed in the burner. With a 16 candle-power lamp, the illuminating power between five and twenty candles increases approximately as the cube of the amount of heat developed. V., 3653.

The new Edison 16 candle-power lamps produce about sixty per cent. more light than the old Edison 16 candle-power lamps. The former have carbons of less radiating surface than the latter and are run at higher temperature. Skill acquired in making the burners has resulted in the smaller carbons having about the same durability as the carbons of the old Edison 16 candle-power lamps. V., 3654-5.

Falling off in illuminating power of a lamp by use is accompanied by increase in the resistance of the burner. In the Franklin Institute tests there was a falling off of about thirty-five per cent. in candle-power after the lamps had been burning one thousand and six hours. V., 3658.

Morton's tests, as given in his Report to the Lighthouse Board in November, 1879, show an average spherical illumination with arc lights of 606 candles per horse-power. V., 3832.

CARBON:

The greater radiating power of carbon and its lower capacity for heat as compared with platinum, contrary to the opinion expressed by Wild, are peculiarities which are of no practical effect upon the question of the superiority of carbon over platinum as the material for an incandescent burner. V., 3598.

In prior lamps there was a real combustion of the carbon. V., 3660.

If, at the time of Edison's French patent for his platinum lamp, a person skilled in the art had had confidence enough in carbon to make experi-

CARBON—(*Continued*):

ments with it, he would have condemned its use for burners of high resistance, and confined his attention to improving the carbon rod burners of prior lamps (which under any circumstances, could only be suitable for use in series lamps) by improving the quality of the carbon. A proof of this is the fact, that when Edison's carbon lamp, with a burner of high resistance, was made known to the public, several scientists at once condemned it as an absolutely impracticable lamp. V., 3819.

At the date of Edison's French patent for his platinum lamp, assuming a person to have had confidence enough in carbon to try it for an incandescent lamp in multiple arc, he would have tried gas carbon, as that was supposed to be the most suitable. As the only method of forming burners from gas carbon was by cutting and filing, the thinner burners, for multiple work, never could or would have been made. V., 3820.

Carbon is fitted for use in incandescent lamps on account of its flexibility and elasticity, among other qualities. This was not recognized by Wild, who stated that the "sole inconvenience" of using carbon is due to the danger of combustion by oxygen of the air, an entirely erroneous statement, for the carbon burner of the lamp of which he was speaking, being surrounded by an inert gas, would not be stable. V., 3827-8.

Prior to Edison's patent, experiments on the effect of different degrees of heat on the conductivity of carbon had been made, but only within narrow limits, and not at temperatures which would enable one to determine the conductivity of carbon when incandescent. V., 3831.

CARBONIZATION:

The burners are brought to a higher state of carbonization by the process of electrically heating them during exhaustion. Under the conditions stated by the patent, the carbon would be subjected to this extra carbonization. V., 3776.

When the terms "carbonized," "carbonization," and "carbonizing," are used in the patent, they refer to the part of the carbonizing process which takes place in the furnace. V., 3778.

There is no statement in the Sawyer-Man patents to indicate that the electric heating was for the purpose of effecting "additional carbonization," or that it produced this result. There is nothing in the patent to indicate that the material was not completely carbonized before the electrical heating began. V., 3780-1.

No instructions in regard to electrically heating the burner during exhaustion, *for the purpose of perfecting the carbonization of the material composing the burner*, are to be found prior to the date of the patent in suit. V., 3783.

COMMERCIAL SUCCESS:

Commercial subdivision of the light has not been dependent upon a lamp of at least 100 ohms resistance hot. V., 3584.

The first successful lamp had the all-glass chamber and a burner of very small diameter, making it possible to use small platinum wires, which could be permanently sealed into the glass without difficulty. V., 3702.

CONDUCTORS:

The ability to subdivide the light in modern incandescent lighting results in a great saving in the cost of conductors leading from the generators to the lamps. V., 3613.

Interest on the cost of conductors enter as a factor into the cost of operating lamps. High resistance lamps allow the use of small conductors. V., 3642.

CROSS-SECTION:

Increased durability, obtained by skill acquired since the date of patent in suit, has made it possible to diminish cross-section of the burner and reduce the strength of the current required. V., 3617.

The new 16 candle-power Edison lamps have smaller cross-section than the old 16 candle-power lamps, are run at higher temperature, and give 60 per cent. more light, with about the same durability. This is a result of skill acquired since the date of patent in suit. V., 3654-5.

Large cross-section of carbon rods in old lamps was a cause of their short life, from the difficulty in obtaining and maintaining durable contact between the carbon rod and large leading-in wires requisite to carry the large current necessary, and from the liability to fracture, the burner not being able to accommodate itself to the effects of expansion and contraction. V., 3665.

Burners of modern lamps with small cross-section are more durable than the carbon rods of the old lamps, because more flexible and easier fastened to the leading-in wires. V., 3666.

Mr. Edison discovered that burners of small diameter had mechanical stability. V., 3688.

The conditions having been laid down by Mr. Edison, the art would be justified in assuming that, if one burner was practically durable, another a little smaller would be also durable. V., 3695.

Mr. Edison discovered that carbons of very small diameter had mechanical stability, and he and others afterwards ascertained this fact for burners of larger diameter. V., 3692.

CROSS-SECTION—(*Continued*):

If Mr. Edison, in the latter part of 1879, had ascertained that burners two or three times smaller in cross-section than those used in former lamps had mechanical stability and were durable, he would not have assumed that burners ten or twenty times smaller would be also stable enough for practical purposes, but would have experimented under the same conditions with smaller burners. If he had started with the size used in the old lamps, and had the means, conditions, and lamp structure necessary to make large burners stable, he would probably have made experiments, using burners ten or twenty or forty times smaller. Persons skilled in the art would have made the same experiments. V., 3700-1.

The minimum size (cross-section) of burner which increased skill and experience enables us to use in an incandescent lamp, is represented by the Edison ten candle-power lamp: it is forty-two ten-thousandths (0.0042) of an inch square. V., 3703.

In 1881 the Edison Company used in their ordinary 16-candle power lamp burners less than 5.6 thousandths (0.0056) of an inch thick by 9.5 thousandths (0.0095) of an inch wide; burners in similar lamps now in use are 4.7 thousandths (0.0047)of an inch square. V., 3703.

The hundred candle-power Edison burner is three times as thick and five and one-third times as wide as the ten candle-power burner, or in absolute figures the hundred candle-power burner has a cross-section of 0.00028224 of a square inch, and the ten candle-power burner, 0.00001764 of a square inch. V., 3704.

The largest and smallest sizes of burners now in use represent the limits within which the art can make practically commercial burners. The art may in the future be able to make practically durable burners, both larger and smaller than those now in use. V., 3705.

The Thomson-Houston Company make a commercial lamp, which has a burner of the largest cross-section of which I have knowledge. It is 0.045 of an inch wide and 0.022 of an inch thick, the area being 0.00099 of a square inch. V., 3705.

Du Moncel did not think the carbon rods used by Lodyguine large enough to be stable. V., 3708.

Since the date of the patent in suit, the efforts of the art have been directed towards obtaining, and have obtained, carbon burners of exceedingly small cross-section. V., 3714.

After the commercial introduction of the modern lamp, it was ascertained that there was use for similar lamps, with burners much larger in diameter than could be made immediately after the date of patent in suit, and the art has succeeded in making such lamps. V., 3714-5.

CROSS-SECTION—(*Continued*):

The invention of the carbonized bamboo burner, since the date of the patent in suit, has enabled the art to make burners with larger or smaller cross-section than before. V., 3715.

The inventions made since the date of the patent in suit have undoubtedly been of some advantage, yet the great factors have been the skill and experience since gained, and without making use of later inventions, the art would have been able to make burners approaching in size the largest and smallest now in use. V., 3717.

Having regard to size and resistance of some modern lamps to be used in multiple arc and to some of those to be used in series, it can be said that the two classes merge into each other. But considered in respect to those lamps of which the greatest number is in commercial use, the sizes and resistances of the two classes of lamps are widely apart. V., 3756.

Cross-section, rather than length, is the controlling factor in determining whether a burner is filamentary. V., 3759.

As to diameter, or cross-section, the burners of the Edison 100 candle-power, and of the Municipal lamps, would be classed among the smaller burners of modern incandescent lamps. V., 3764.

In April, 1879, a person skilled in the art starting out to substitute carbon for platinum in an incandescent lamp, would have tried carbon rods like those used in prior lamps, and meeting with failure, would never have gone far enough to even consider the question of adapting the burners to use in multiple arc or in series. Fontaine, in attempting to subdivide the electric light, made experiments with lamps in multiple arc and series, but used the *same* lamps in each case, not attempting to adapt the resistance of the lamps to the conditions under which they were arranged in circuit. The art would not have known in April, 1879, that the burners would have to be shaped different to adapt them for use in multiple arc and in series. V., 3816.

CURRENT:

Since the art of modern incandescent lighting began, the amount of current requisite for a 16 candle-power lamp has been reduced about forty per cent. V., 3616.

In modern incandescent lamps, on a multiple arc circuit, the amount of current required is proportional to the number of lamps. V., 3617.

With Edison lamps and a given amount of current, the same total illuminating power will be obtained, whether the lamps be 100 candle-power or 16

CURRENT—(*Continued*):

candle-power each. The electro-motive force, the amount of electrical energy, and the economy will be the same in both cases. V., 3625.

Current required in prior lamps, which had thick burners, was great in comparison with the amount required for filamentary burners of modern lamps. V., 3614.

DISCOVERY:

Edison discovered that carbon, when heated to incandescence in a vacuum by the passage of an electric current through it, is stable, and that this is true even when the carbon is small in diameter and seemingly very fragile. When Edison's invention was first announced to the public, several scientific men pronounced the invention a failure, because they believed there would be no durability on account of the destructive action of the heat and current. They did not know that there was any virtue in the use of a high vacuum. V., 3668.

Mr. Edison discovered that in a high vacuum even a thin burner would endure for several hundred hours. Considered as a matter of common sense and its effect upon commercial electric lighting, this certainly amounted to a discovery of the stability of carbon. V., 3670.

Mr. Edison's discovery was that carbon is practically stable when all gases are removed from its presence. His *invention* was the lamp described in the patent in suit. V., 3682.

Edison's invention, so far as it was the outcome of any discovery, was based upon the discovery that a carbon burner, even when small in diameter and of high specific resistance, would be practically stable, when enclosed in a globe from which all gases had been permanently removed. V., 3683.

DURABILITY:

Prior to date of patent in suit incandescent carbon burners had little durability, and were believed to be necessarily limited to a life of a few hours, even when made quite thick. V., 3589.

Increased skill acquired since the patent in suit has resulted in an increased durability of the burners and has made it possible to reduce the cross-section of the filament, to run it at higher incandescence and to reduce the strength of the current. V., 3617.

When the patent in suit described the method of making durable lamps, the problem of subdivision was solved. V., 3631.

DURABILITY—(*Continued*):

Knowing that the seemingly fragile burner of Edison's lamp was durable, persons skilled in the art would have known how to change the burner, so as to get lamps of any required illuminating power. V., 3633.

A single durable and economical lamp, made by the process of the patent in suit, would have solved the problem of subdivision, even assuming it to have been 250 candles and but four ohms resistance. V., 3635 6.

Burners of modern incandescent lamps are more durable than formerly, and can be operated at higher temperature and incandescence. V., 3640.

There is no marked difference in durability between the thin carbon filaments of the Edison 16-candle-106-volt lamp and the thicker filament of the 16-candle-61-volt lamp. V., 3651.

Acquired skill allows the making of thinner filaments for the new 16 candle-power lamps, which are run at higher temperature, with 60% more light, and have about the same durability as the thicker filament in the old 16 candle-power Edison lamp. V., 3654 5.

There is really no such thing as "wearing out" of a carbon burner. No rational explanation has been yet propounded to explain why a filament breaks. We only know the fact of their breaking, and that they will last longer made of one material than of another. No change in the diameter from use is perceptible to warrant the assumption that breaking is caused by wearing away. V., 3656

By far the greater number of all lamps in use are replaced because they break, and not because they fall off in efficiency or because the globes become blackened. V., 3659.

The exceedingly small amount of oxygen left in lamp chamber of modern incandescent lamps does not impair the durability of the burner. V., 3663.

The short life of old lamps was due in great measure to thick carbons, which made it difficult to obtain and preserve durable contact between the carbon rod and leading-in wires, on account of the large current required and the liability of the burner to fracture on account of its rigidity and the inability of the thick carbon to accommodate itself to the contraction and expansion when heated and cooled. V., 3665.

Modern lamps with small cross-section of burner are more durable than the old lamps with carbon rods because the burners are more flexible, and their points of contact with leading-in wires can better withstand the effects of the small amount of current required. V., 3666.

DURABILITY—(*Continued*):

Prior to patent in suit it was not supposed that the amount of gas in the globe had anything to do with durability, provided the globe contained no oxygen. V., 3670.

Durability was to be obtained, according to Greener & Staite, simply by using a purer carbon. V., 3676.

It is only through the great skill and experience acquired since the date of patent in suit that it has become possible to make durable burners as large as are used in the largest modern lamps. V., 3694.

A burner of paper, made by any process of carbonization known prior to 1879, of the size of the Edison new 16 candle-power lamp, or the size of the new 10 candle-power lamp, would not be durable, even if subjected to the hydro-carbon treatment and electrically heated while on the pump. Made of any size, such a burner would not be durable, unless electrically heated on the pump. V., 3697.

The durability of a burner depends upon the electro-motive force at which it is run. V., 3718.

Durability and efficiency do not improve in proportion to the perfection of the vacuum up to the highest attainable limit. V., 3720.

It was known at the date of patent that electrically heating the carbon burner in the presence of an inert gas expelled the air from the pores of the carbon, and that by removing this occluded gas from the lamp chamber the durability of the lamp would be improved. V., 3779.

DYNAMOS:

The invention of the Gramme and Siemens machines furnished the means for producing electricity in large quantity and economically. V., 3562.

ECONOMY:

The invention of the Gramme and Siemens' machines furnished the means for producing electricity in large quantity and economically, but these, in conjunction with the Lodyguine lamp, did not solve the problem of subdivision. V., 3562.

An incandescent lamp for which a commercial demand exists, is an economical lamp. V., 3637.

Arc lights are not so economical as is popularly supposed in comparison with incandescent lights. Commercially they produce, on the average, only twice the total amount of light that is produced by incandescent lights with the same amount of power, and on account of the impossibility of usefully applying the light to interior lighting, they are not so economical for that purpose as incandescent lamps. V., 3639.

ECONOMY—(*Continued*):

In 1880 and 1881, the total number of candles of light per horse-power was about sixty per cent. of that produced by the lamps now manufactured by the Edison Company. This improvement is due, not to any changes in lamp construction, but to more durable burners, capable of being operated at a higher temperature and incandescence. It is due, to some extent also, to improvements in means for generating and distributing the current to the lamps. V., 3640.

Economy does not necessarily vary as the electro-motive force employed to operate the lamp. Where power is cheap, economy may be increased by reducing the electro-motive force; where power is dear, the economy may be increased by raising the electro-motive force. V., 3641.

The experiments of Foussat and Siemens do not prove the commercial value of operating incandescent lamps at an electro-motive force greater than the normal. V., 3644-7.

EFFICIENCY:

There is a gradual falling off in efficiency in incandescent lamps, becoming greater and greater until the lamps fail by breaking of the carbon. This is shown by the Franklin Institute tests, and by those of Siemens. V., 3658.

By far the greater number number of electric lamps are replaced because they break, and not because of the reduction in their efficiency. V., 3659.

The trifling amount of combustion taking place results in a very minute reduction in the efficiency of the modern lamp, but is not sufficient to have any practical effect on the commercial value of the lamp. V., 3664.

ELASTICITY AND FLEXIBILITY:

Burners with small cross-section are more durable than the carbon rods of old lamps, because they are more flexible. V., 3666.

ELECTRO-MOTIVE FORCE:

For best results the electro-motive should not be increased above the normal. V., 3644-7.

The electro-motive force at which a lamp should be run is determined by measuring the amount required to operate it when producing its normal amount of light. V., 3647.

Although the patent in suit does not give any specific directions as to the electro-motive force to be used, the art would have known, or determined, the proper electro-motive force at which to operate the lamps. V., 3719.

ELECTRO-MOTIVE FORCE—(*Continued*):

The amount of current that will heat a hundred feet of wire will heat a thousand, cooling effects being the same, but the electro-motive force necessary to cause the electricity to flow through it, is proportional to its length, and this, whether the wire is divided up into many small parts connected in series, or left in one piece. V., 3724.

It was understood long prior to 1879 that, when lamps were to be connected in series, the electro-motive force should be increased as lamps were added. V., 3725.

Subdivision was accomplished by means of lamps connected in multiple arc, in which case the electro-motive force does not have to be increased as lamps are added. V., 3725 6.

EVAPORATION:

In addition to the combustion of carbon in prior incandescent lamps, it was subject to a rapid evaporation. The thin filaments of modern incandescent lamps cannot be destroyed by combustion, and there is no evaporation which prevents the lamps having a great commercial value for several hundred hours. V., 3661-2.

Evaporation does not cause the breaking of modern incandescent lamps. V., 3662.

In 1877, Fontaine obviously considered the evaporation of incandescent carbon as a necessary evil, and that it was not due in any way to the presence of gas in the globe, for he says that it would seem that the carbon ought to be preserved indefinitely in an inert gas. V., 3671.

FILAMENT:

The term "thread-like" is properly applicable to all commercial lamps made by the Edison Company. The Heissler, and the Bernstein largest series lamps, and some of the lamps made by the Thomson-Houston Co., cannot properly be termed "thread-like." V., 3745.

The smallest burner made by the Thomson-Houston Co., which cannot properly be called thread-like, is 1.15 times thicker and 1.9 wider than the largest Edison burner, and the area of cross-sections of the former is 2.15 times that of the latter. The Thomson-Houston burner is 0.04059 of an inch wide and 0.017 of an inch thick, giving an area in cross-section of 0.00069003 of a square inch. The Edison burner is 0.0217 of an inch wide and 0.0148 thick, giving an area of cross-section of 0.00032116 of a square inch. The area of cross-section of the largest Thomson-Houston burner made is 0.00059332095 of a square inch, and that of the smallest is 0.000345876 of a square inch. V., 3746.

FILAMENT—(*Continued*):

The largest Edison burner is small enough to be called thread-like, but the definition would not properly apply to the largest of the Thomson-Houston burners. V., 3746.

Consensus of opinion might locate a dividing line between a thing that is thread-like and a rod, or at least reduce the doubtful region to quite narrow limits. If a burner of given size is small enough to be called thread-like, certainly burners smaller than this also come under the same definition. V., 3747.

The term "thread-like" is generally applied to those objects whose diameter is comparable to that of ordinary thread. V., 3748.

Fontaine calls the burners used in his experiments "rods." The width of the largest Edison carbon is approximately $\frac{1}{3}$, its thickness $\frac{1}{4}$, and its area of cross-section nearly $\frac{1}{10}$ that of Fontaine's rod. The width, thickness and area of cross-section of the Thomson-Houston burner under consideration are respectively $\frac{2}{3}$, $\frac{3}{10}$ and between $\frac{1}{4}$ and $\frac{1}{3}$ that of Fontaine's rod. V., 3749.

The fact that the Edison burner is bent into the hairpin, or horse-shoe form, or that it is made of a material allowing its being brought into this shape, has nothing to do with its being classed as "thread-like" or "filamentary." The fact that the burners of old carbon lamps were straight has nothing to do with their being classed as "rods." V., 3851.

The Edison Municipal lamps are adapted for use in series only, and have "thread-like" or "filamentary" burners. "Filamentary" or "rod" has reference to cross-section rather than length. V., 3757.

Whether a burner is to be considered filamentary depends to some extent upon its length, but diameter or cross-section is the controlling factor. V., 3759.

A burner one-fourth of an inch in length, and of a cross-section one-fourth or one-tenth that of the Municipal burner, would be filamentary, because the general sense in which the term is used would make it applicable to this burner, in that it is small and slender. V., 3759-60.

A body would be called slender, if the length were fifty times its diameter. V., 3763.

The burners of the Edison 100 candle-power and Municipal lamps would be classed, as to diameter or cross-section, among the smaller burners of modern incandescent lamps. V., 3764.

The burner in the lamp which Dr. Adams said he made would not be classed as a filament. V., 3855.

FILAMENT OF CARBON:

Citations from the literature relating to the wasting away of incandescent carbon and to the sceptical spirit with which scientists received the announcement of Edison's invention, indicate that the substitution of a carbon filament, in place of a platinum wire in a high vacuum, would not have been an obvious thing to do, or a mere matter of engineering. V., 3591–7.

Filamentary burner of modern lamps requires only comparatively feeble current, as compared with large burners in prior lamps. V., 3614.

The resistance of the filament is made as high, and the amount of its surface as low, as is consistent with sufficient durability, at the same time having in mind the production of the required amount of light with the least practicable expenditure of power. This is shown to be Maier's opinion by quotations from his work on, "Arc and Glow Lamps." V., 3647–51.

There is not much more power to resist shocks, concussions, and high temperature in the thick filament of the 16-candle–61-volt Edison lamps than in the thin filament of the 16-candle–106 volt lamps. V., 3651.

The filaments of the 61-volt Edison lamps are operated at the same temperature as the 106-volt lamps. V., 3652.

Acquired skill permits making the carbon filaments in the new Edison 16 candle-power lamps smaller than in the old 16 candle-power lamps; they can be run at higher temperature, have about the same durability as the old thicker filaments, and produce about 60% more light. V., 3654–5.

Carbon filaments do not wear out, and no rational explanation of why they break has been given. V., 3656.

The filaments of modern incandescent lamps are not destroyed by combustion, and there is no evaporation which prevents the lamps having a great commercial value for several hundred hours. V., 3661–2.

Edison discovered that carbon, when heated to incandescence by the passage of an electric current through it, is stable, even when it is small in diameter and seemingly very fragile. V., 3668.

Du Moncel, from his knowledge of the prior art of incandescent lamps, upon hearing of Edison's invention, expressed the opinion that the heat would soon destroy the small, slender burner of the Edison lamp. V., 3694.

The minimum size of burner which increased skill and experience enables us to use in an incandescent lamp, is represented by the Edison ten candle-

FILAMENT OF CARBON—(*Continued*):

power lamp; it is forty-two thousandths (0.0042) of an inch square. V., 3703.

If it had been ascertained that the carbon rod used in the old lamps were stable, no one would have been justified in assuming the utility of making a filament, for the art would have considered that it was the size of this carbon rod that made it stable. V., 3706.

The term "filament," is first used in connection with incandescent lighting in the patent in suit; it is to-day applied by electricians to all the burners of both multiple arc and series lamps. V., 3734.

In the art to-day "filament" and "burner" are used synonymously. V., 3738.

No statement of any kind is made, prior to the patent in suit, concerning carbonized thread or carbon filament burners. V., 3786.

Larger burners, as well as those of filamentary form, can be made by the process of the patent in suit. V., 3805.

A lamp with a filamentary burner in a high vacuum in an all-glass globe, is described for the first time in the patent in suit. V., 3815.

As contrasted with carbon rods used as burners in old lamps, the filament of carbon is flexible and elastic, while the carbon rods are rigid. V., 3821.

GASES:

For several years prior to patent in suit, efforts to obtain a practical lamp were mainly in the direction of a lamp chamber filled with inert gas, to prevent combustion. The lamps of Lodyguine, Konn, Sawyer-Man, &c., whose experiments were concurrent with the earlier efforts of Edison, were held by the art to give most promise of success. V., 3587.

Directions in Greener & Staite's patent, to place carbon in air-tight vessel, mean simply that oxygen is to be removed. V., 3677.

From what Professor Morton said in 1878 in his lecture on the electric light, it is apparent that he did not recognize that deterioration of the carbon in prior lamps was caused by gases other than oxygen. V., 3681.

At the date of the patent in suit it was generally understood that, by means of lamp chambers filled with inert gases, the detrimental effect of the oxygen had been overcome, but still the burners were not durable. V., 3683.

GASES—(*Continued*):

Electrical heating as described in the Sawyer-Man patents, is always to take place in the presence of a nitrogen gas. V., 3781.

Occluded gases cases can only be removed from the burner by electrical heating. V., 3810.

It was not until the discovery that carbon would be stable in a high vacuum that the detrimental effect of the presence of inert gas became known. V., 3830.

Inert gas operates by "air-washing" to bring about the destruction of the carbon. V., 3830.

GENERATORS OF ELECTRICITY:

Prior to 1879 it was known how to arrange a battery or other generator so that several lamps could be kept in action by the same generator. V., 3823.

HEATING DURING EXHAUSTION:

A paper carbon burner of the size used in the new Edison 16 candle-power lamp, or in the 10 candle-power lamps, made by any process of carbonization known prior to 1879, without being subjected to the hydro-carbon treatment or electrical heating while on the pump, would not be durable. If of this size, it would not be a practical burner, even if subjected to the treatment mentioned. Made of any size, it would not be practically durable, unless electrically heated on the pumps. V., 3697.

With materials other than paper, the carbon burner is brought to normal, or little above normal, incandescence by heating on the pumps, in order to expel the gas from the pores of the carbon. This is found necessary irrespective of the size of the burners, at least for all sizes between the smallest and largest used in modern incandescent lamps, even if they have received the hydro-carbon treatment. V., 3698-9.

All Edison burners are electrically heated subsequent to the carbonization and while the lamp bulb is being exhausted. This reduces the specific resistance about 20%. V., 3773.

The patent in suit instructs the art to apply electrical heating to the carbon burner, by insisting upon the necessity of a high vacuum. This was a well-known means of obtaining high vacuum. V., 3774-5.

The burners are brought to a higher state of carbonization by the process of electrically heating them during exhaustion. Under the conditions stated by the patent, the carbon would be subjected to this extra carbonization. V., 3776.

HEATING DURING EXHAUSTION—(*Continued*):

It was known prior to the patent in suit that, by electrically heating a carbon burner in the presence of an inert gas during exhaustion, the air in the pores of the carbon would be expelled and that by removing this occluded gas from the lamp chamber, the durability of the carbon burner would be increased. V., 3779.

The directions given in the patent in suit, taken in conjunction with the Sawyer-Man patent and Edison's platinum lamp patent, would be sufficient to instruct the art to electrically heat the carbon burner during the process of exhausting the globe, for the purpose of aiding the pump in perfecting the vacuum; the process results also in additional carbonization. V., 3780.

The Sawyer-Man patents contain no statement that the electrical heating was for the purpose of additional carbonization, or of securing a higher vacuum, or that it was to be applied to any other form of carbon burner than a pencil, and it is always to be employed in the presence of a nitrogen gas. V., 3780-1.

Electrical heating during exhaustion is absolutely essential to the construction of a practically useful lamp. V., 3783.

The references in the patent in suit to the necessity for a very high vacuum would lead the art to understand the necessity of electrical heating, because the patents of Sawyer-Man teach that there is air in carbon, which is expelled from it by electrical heating, but which acts injuriously if allowed to remain in the lamp chamber. Moreover, the English and French patents of Edison teach that a platinum burner contains air in its pores, and that by expelling this air by electrical heating during the process of exhausting the globe, a very high vacuum is obtained. The Edison French and English patents likewise refer to the fact that the air contained in sticks of carbon may be expelled in this manner. Prof. Elihu Thomson, one of defendant's witnesses, states that the Sawyer-Man patents describe a process of heating the carbon to drive the air and gas out of the burner, and that Edison's French patent describes it in connection with his platinum lamp, and refers to it as being suitable for use with carbon. He furthermore expresses the opinion that proper skill and judgment would lead one, in reading the patent in suit, to electrically heat the carbon during exhaustion, to drive the air out of the carbon and to obtain a high vacuum. V., 3785.

Without electrical heating the vacuum is so low that the burner is soon destroyed; with it the vacuum is so high that the burner is durable. V., 3787-8.

With electrical heating, it is possible to obtain a vacuum as high as that mentioned in the patent, viz., one-millionth of an atmosphere. Without electrical heating, the vacuum would not be half as high as with it, assuming the carbon burner to be of filamentary size. V., 3788.

HEATING DURING EXHAUSTION—(*Continued*):

In electrical heating it is necessary to carry the temperature to a point higher than that at which the burner is to be run in practice. V., 3792.

The object of electrically heating the carbon sticks or pencils, as mentioned in the French and English Edison patents, was to free the carbon from air, in order to make them "very homogeneous and hard." This process would result in additional carbonization, if they were not already perfectly carbonized. V., 3792.

There is only one process known for driving out of the burner the occluded gas, and this is electrical heating. This fact, and the reference to an almost perfect vacuum in the patent, make a specific reference therein to electrical heating unnecessary. V., 3810.

The expressions used in the Sawyer-Man patents, as well as in Edison's English and French patents, show that, in removing the occluded gases from the burner, the latter is to be raised to higher temperature than normal incandescence. V., 3810-11.

I have come into possession of facts, concerning tests which have been made, which convince me that I have been in error heretofore, as to the absolute necessity of electrically heating the burner during the exhaustion of the globe, in order to obtain a lamp which would have been durable enough for practical purposes at the date of the patent in suit. On the contrary, electrical heating would not have been necessary with a lamp like that described in said patent, having a carbon burner of small mass, and not having large metallic parts enclosed in the glass chamber, although good skill and judgment would, in view of the prior state of the art and the instruction contained in the patent, have suggested the use of this method, in order to obtain the best possible lamp. V., 3851.

INVENTION INVOLVED:

The possibility of preventing the rapid destruction of carbon burners was not known until Edison discovered, as stated in the patent in suit, that even a burner made of carbonized thread would be stable in a high vacuum in an air-tight chamber. The construction of a lamp which made it possible to take advantage of this property of carbon and to use a burner of filamentary form, thus making incandescent lighting commercially possible, was an invention of great merit and utility. V., 3590.

The authorities cited showed that the substitution of a carbon filament in place of a platinum wire in a high vacuum, would not have been a mere matter of engineering. V. 3597.

Irrespective of the fact that Edison did discover the stability of carbon in a high vacuum, it required invention to bring together into one combination the all-glass chamber with platinum conducting wires fused into

INVENTION INVOLVED—(*Continued*):

its walls, and containing a carbon burner of small diameter in a high vacuum, the whole being so ordered and arranged as to result in a practically durable lamp, like that described in the patent in suit by the use of which the problem of subdivision would be solved. V., 3684.

If a burner as large and of such low resistance as to be adapted for use in series only had, at the date of the patent in suit, first been enclosed in a lamp chamber like that described therein, it would not have required invention to substitute in its place a small burner of high resistance adapted for use in multiple arc, provided the methods by which the large burner was made, were adapted to the construction of the small burner. The assumption, however, is contrary to the facts. Multiple arc lamps were first made, and series lamps with large burners were a later development of the skill and experience acquired since the date of the patent in suit. V., 3752-3.

KING'S LAMP:

King's and Roberts's patents do not contemplate the use of the almost perfect vacuum mentioned in the patent in suit. V., 3588.

King's patent does not describe a lamp having an all-glass chamber. V., 3587.

LAMP, ARC:

Arc lamps, on the average, produce commercially only twice the quantity of light produced by incandescent lamps with the same amount of power. V., 3639.

LAMP CHAMBER:

For several years prior to patent in suit the efforts of the art were directed mainly to the use of chambers filled with some inert gas, to prevent combustion. Lodyguine, Konn, Sawyer-Man worked in this direction, and their lamps were considered by the art to give the most promise of success. V., 3587.

Glass plates, or stoppers, for closing lamp chamber, referred to in the Sawyer-Man patent, are in every respect equivalent to the metallic base mentioned in Edison's patent as having been used in prior lamps. Statement in patent in suit to the effect that prior lamps had metallic bases is correct. V., 3587.

King's patent does not describe a lamp having an all-glass chamber. All prior carbon lamps had glass chambers closed with metallic bases, or their equivalents. V., 3587-88.

The construction of prior lamps, and the method of obtaining vacua, made it impossible to obtain and preserve a vacuum in such lamps, which was at all comparable to that contemplated by patent in suit. V., 3588.

LAMP CHAMBER—(*Continued*):

Lodyguine and other inventors considered it only necessary to expel oxygen from the lamp chamber, and they were unable to overcome the fatal inconvenience of the wasting away of the carbon. V., 3598.

On account of defective construction of lamp chamber, and of the air contained in the carbon of prior lamps, there was real combustion of the burner. V., 3660.

The exceedingly small amount of oxygen left in lamp chamber of the modern incandescent lamp has no effect upon its commercial value. V., 3663.

Roberts considered that it was only necessary to remove the oxygen. Roberts would not have obtained a good vacuum by using a Sprengel pump, because his lamp chamber leaked. V., 3667.

The history of the art shows that attempts were made to diminish the leakage of air into the chambers of the old lamps, but the impossibility of accomplishing it with the separable lamp chamber led to abandonment of the use of vacua and the substitution of gas, which would not burn the carbon and would keep the air out. V., 3667.

The first successful lamp had the all-glass chamber and a burner of very small diameter, making it possible to use small platinum wires, which could without difficulty be permanently sealed into the glass. V., 3702.

LAMP, INCANDESCENT:

Commercial development since the date of the patent in suit has not shown that lamps must have so high a resistance as 100 ohms in order to render subdivision practicable. V., 3584.

De Changy's platinum spiral-wire lamp was not intended to be air-tight. V., 3600.

Incandescent lamps are more economical for interior lighting than arc lights. V., 3639.

With Edison lamps the total number of candles of light produced per horse-power is the same, whether lamps of 100 candle-power or of 16 candle-power are employed. V., 3639.

Prior to 1879 it was known how to arrange a battery or other generator so that several lamps could be kept in action by the same generator. V., 3833.

LAMPS, SEMI-INCANDESCENT:

The semi-incandescent principle was at one time a favorite mode of attempting subdivision, but was abandoned about 1881. V., 3568.

LEADING WIRES:

If, prior to patent in suit, carbon burners of from one to four ohms resistance, or less, had been placed in chambers having low vacua, or filled with inert gas, loss of heat would have reduced the temperature and illuminating power of the burner, and the increased current required to bring the burner to its normal temperature and incandescence would necessitate leading wires too large to be fused into the glass; thus cement joints, liable to leakage, would be used. Lamps with large platinum leading-in wires were not made until several years subsequent to patent in suit, and were only possible on account of increased skill and experience gained since that date. V., 3589.

LENGTH:

The 100 candle-power Edison lamps have burners about the same in cross-section as the 15 candle-power Municipal lamps, but the length and resistance of the former are nearly eight times those of the latter. V., 3757.

Whether a burner is filamentary depends to some extent upon the length, but cross-section is the controlling factor. V., 3759.

MULTIPLE ARC:

Subdivision was accomplished by arranging lamps in multiple arc, not in series. V. 3725-6.

The reason for saying that subdivision was accomplished by lamps arranged in multiple arc, is the fact that after the invention described in the patent in suit, lamps adapted for use in multiple arc were first made by Mr. Edison and others. By far the greatest part of incandescent lighting is done to-day by lamps arranged in multiple arc. Only after the multiple arc arrangement had come into extensive use, was the use of series lamps taken up, and the number of series lamps for incandescent lighting in use to-day is not more than five per cent. of the total number. V., 3731.

The patent in suit describes an incandescent lamp possessing characteristics which make such lamps eminently adapted to use in multiple arc. V., 3732-3.

Lane-Fox's English patent of 1878 points out, but indefinitely, the relation of a small burner to multiple-arc distribution, but it is doubtful whether the views generally held prior to the date of the patent in suit, as to the impossibility of subdividing the light, would have led the art, from Lane-Fox's patent, to substitute a small carbon burner adapted for use in multiple arc, in place of a large burner adapted for use in series. V., 3754.

Lane-Fox points out the necessity of small size and high resistance, when the lamps are arranged in multiple arc, "*so that there may not be very great loss from the resistance of the conducting mains or conductors.*" V., 3754.

MULTIPLE ARC—(*Continued*):

Lane-Fox lays special emphasis on the arrangement in multiple arc, and has one or more claims in his patent relating thereto. V., 3754.

Having regard to size and resistance of some modern lamps to be used in multiple arc and to some of those to be used in series, it can be said that the two classes merge into each other. But considered in respect to those lamps of which the greatest number is in commercial use, the sizes and resistances of the two classes of lamps are widely apart. V., 3756.

In April, 1879, the art would not have known that burners must be shaped differently to adapt them for use in multiple arc and in series. In view of the fact that carbon rod burners had been found to be without stability up to this time, and that a burner for use in multiple arc would have to be long and thin, the idea of making such a burner at that date would not have occurred to any one. V., 3817.

In June, 1879, a person skilled in the art would have known that burners for multiple arc work should have a comparatively high resistance, and for series work, a comparatively low resistance. V., 3819.

Gaudoin's process was suitable for making carbons to be used in multiple arc and was known prior to the date of patent in suit. This process contemplated the reduction of suitably selected wood to the definite form the carbon was to have, and its subsequent carbonization. V., 3831.

Carré's earlier method of making carbons could hardly be practically utilized in producing carbons for multiple arc lamps. V., 3831.

PATENT IN SUIT:

In a brief and general way, the patent in suit correctly gives the state of the art as regards important features of prior lamps. V., 3585.

Edison's lamp described in patent in suit is one employing a carbon burner, and the patent, in speaking of prior incandescent lighting, obviously refers only to lamps in which carbon burners were used. V., 3586.

The statement in patent in suit, that the carbon rod burners of prior lamps had from one to four ohms resistance, is not disproved by the statements in prior patents. V., 3586.

Omission to mention prior lamps in which vacuum is used, is quite immaterial, since those of most promise used chambers filled with inert gas. V., 3587.

describes the invention constituting the practical solution of the problem of subdividing the electric light. V., 3629.

PATENT IN SUIT—(*Continued*):

accomplished subdivision by making known the method of constructing practical incandescent lamps capable of use in multiple arc in considerable numbers. V., 3630.

describes a lamp construction adapted to the making of lamps suitable for use in series. V., 3630.

describes a method of making a lamp capable of wide variations in resistance. V., 3635.

describes an invention, which consists of bringing together into one combination the all-glass chamber, with platinum conducting wires fused into its walls, and containing a carbon burner of small diameter in a high vacuum, the whole being so arranged as to result in a practically durable lamp, by which the problem of subdivision was solved. V., 3684.

No specific directions are given, and none were necessary, in the patent in suit, as to the electro-motive force to be used. The patent describes a method of making burners varying widely in resistance, extent of radiating surface, and candle-power, and hence requiring different electro-motive forces. The art would have recognized the commercial value of such lamps, and by the testing them determined the proper electro-motive force. V., 3719.

The invention described in the patent in suit is for an incandescent lamp possessing characteristics which make such lamp eminently adapted for use in multiple arc. V., 3732.

is not necessarily limited to lamps having a resistance high enough to make them suitable for use in multiple arc. V., 3733.

first uses the term "filament" as applied to the burner of an incandescent lamp. To-day the term is applied to the burners of both multiple arc and series lamps. V., 3734.

describes the making of a lamp having high specific and high total resistance. V., 3766.

While the process of making burners described in the patent in suit is applicable to the making of burners of low total resistance and comparatively large radiating surface, it is the only process by which they can be made of high total resistance and small radiating surface. The process of the patent in suit gives to the carbon high specific resistance. V., 3767.

instructs the art to apply electrical treatment to the carbon burner, by setting forth the necessity for a very high vacuum in the lamp; electrical heating, being the well-known and only way of obtaining this high vacuum, would naturally be applied. V., 3774–5.

PATENT IN SUIT—(*Continued*):

The terms "carbonized," "carbonization," and "carbonizing," when used in the patent in suit, refer to the part of the carbonizing process taking place in the furnace. V., 3778.

Nowhere outside of the patent in suit do we find instructions in regard to the electrical heating of the carbon burner of an incandescent lamp, during the process of exhausting the globe, for the purpose of perfecting the carbonization of the material composing the burner. V., 3783.

Prior to patent in suit it was not known that any advantage would result from placing a carbon burner in a very high vacuum, or that by so doing a carbon burner could be made durable enough for commercial purposes. The patent in suit calls attention to the absolute necessity of exhausting the lamp chamber to a very high degree, by stating that the burner is to be placed "in a *nearly perfect vacuum*, to prevent oxidation and injury to the conductor by the atmosphere"; that "there must be *almost a perfect vacuum* to render the carbon stable"; and that "a carbon thread properly carbonized and placed in a sealed glass bulb exhausted to *one-millionth of an atmosphere* offers from one hundred to five hundred ohms resistance to the passage of the current, and that it is absolutely stable at high temperature." Patent also states that the globes of old lamps cannot be kept tight, and that for this reason the carbon is consumed. Reference is also made to the lamp chamber of one continuous piece of glass, as a "*vacuum bulb*," hermetically sealed when a "*high vacuum*" is reached: that platinum is the only material that can be used for leading-in wires, because its expansion is nearly the same as glass; and, again, that the current is conducted into the vacuum bulb through these wires, which are "sealed" into the glass, and that because they are small in resistance as compared with the burner, *fine* wires may be used that will not heat and crack the "*sealed vacuum bulb*." V., 3784-5.

describes the only known practical process of making burners. V., 3800 2.

describes a process applicable to the making of burners larger than those of filamentary form. V., 3805.

does not contain the earliest description of a process which might be employed in making carbon burners, whereby they can be produced of such size and resistance as to adapt them for use in multiple arc. One such process was known, but no burners having been made under this method suitable in size and resistance for use in multiple arc, and there being other unsuitable processes in existence, it was important that the patent should ascertain and announce the practicable process. V., 3807-9.

contains a description of lamp construction and methods to be pursued in making different parts of the lamp. V., 3808.

PATENT IN SUIT—(*Continued*):

describes for the first time a carbon burner in a high vacuum in an all-glass globe, and also for the first time a similar lamp with a filamentary carbon burner. V., 3815.

RADIATING SURFACE:

Wild was wholly without appreciation of the function performed by the radiating surface of a burner. His statement that a carbon rod fifteen times thicker than a platinum wire will, with the same current, engender the same amount of heat, is correct, but an amount of heat sufficient to make a platinum wire incandescent would not raise the carbon rod to a temperature at which it would give out any light. His report contributed nothing to the existing knowledge, was inaccurate and misleading, and any one following his directions would certainly have failed. V., 3599.

The radiating surface, the amount of light, and the quantity of power required, are the same in the 61-volt and in the Edison 106-volt lamps. V., 3651-3.

The patent in suit describes a method of making burners having a small radiating surface. V., 3765.

With carbons of high specific resistance the ratio of the total resistance to the extent of surface is greater than with carbons of low specific resistance. V., 3767-8.

RESISTANCE:

At the date of patent in suit the problem of subdivision of the light as then understood did not require a lamp of at least 100 ohms resistance hot. V., 3582.

The resistance of two sizes of lamps should be inversely as their illuminating powers. V., 3625.

Change in resistance alone would not be sufficient to subdivide the light: the length, diameter, and surface of the burner must be taken into consideration. V., 3625.

Patent in suit describes a method of making a lamp capable of wide variations in resistance. V., 3635.

It is desirable that the resistance of the lamps should be as great as is consistent with making them practically durable, in order to keep down the cost of conductors and amount of current required. V., 3642.

Resistance of the filament is made as high as is consistent with sufficient durability, having in mind the production of the required amount of light with the least practicable expenditure of power. V., 3647.

RESISTANCE—(*Continued*):

Lamps begin to lose in efficiency soon after they are put on the circuit. The falling off in illuminating power is accompanied by an increase in resistance that reaches about seven per cent. V., 3658.

Increase in the resistance of burners is caused by diminution of the mass of the carbon in the burner. V., 3660.

Lane-Fox, in 1878, in speaking of lamps arranged in multiple arc, points out the necessity of small size and high resistance, "*so that there may not be very great loss from the resistance of the conducting mains or conductors.*" V., 3754.

Having regard to size and resistance of some modern lamps to be used in multiple arc, and to some of those to be used in series, it can be said that the two classes merge into each other. But considered in respect to those lamps of which the greatest number is in commercial use, the sizes and resistances of the two classes of lamps are widely apart. V., 3756.

The patent in suit describes making a lamp of high total and high specific resistance. V., 3766.

In April, 1879, a person skilled in the art starting out to substitute carbon for platinum in an incandescent lamp, would have tried carbon rods like those used in prior lamps, and meeting with failure, would never have gone far enough to even consider the question of adapting the burners to use in multiple arc or in series. Fontaine, in attempting to subdivide the electric light, made experiments with lamps in multiple arc and series, but used the *same* lamps in each case, not attempting to adapt the resistance of the lamps to the conditions under which they were arranged in circuit. The art would not have known in April, 1879, that the burners would have to be shaped different to adapt them from use in multiple arc and in series. V., 3816.

In view of the state of the art, no one in June, 1879, immediately after the issue of Edison's French patent for his platinum lamp, would have been led to substitute carbon for platinum as a burner, nor to make such a burner of high resistance. V., 3818.

In June, 1879, a person skilled in the art would have known that a carbon burner, if it could be made durable, must have comparatively high resistance for multiple arc work and comparatively low resistance for series work. V., 3819.

After the date of Edison's French patent for his platinum lamp, a person skilled in the art would have condemned carbon as material for a burner of high resistance, and tried to improve the carbon rods of the old lamps. After the advantages of a burner of high resistance for use in multiple

RESISTANCE—(*Continued*):

arc were pointed out by the French platinum patent, no one appears to have attempted to make burners of high resistance out of carbon. When the description of Edison's carbon lamp with a burner of high resistance appeared, several scientists at once condemned it as an absolutely impracticable lamp. V., 3819.

Assuming that a person had confidence enough in carbon to experiment with it prior to the patent in suit, he would have tried to make burners from gas carbon, and, as this must be shaped by cutting and filing, it would have been impracticable to make burners of high resistance out of it. From what was understood as to the rapid consumption of the burners when heated to incandescence, and the conditions under which it was stable being unknown, it would not have been attempted to make high resistance burners from this material. V., 3820-1.

RESISTANCE, SPECIFIC:

The result of the process described in the patent in suit is a carbon burner of high specific resistance. V., 3767.

Great advantage of the process of patent in suit, is the production of burners whose carbon has a high specific resistance, from which it results that the ratio of the total resistance of the burner to the extent of its surface is greater than if the carbon were of low specific resistance. V., 3767-8.

Carbon of high specific resistance means carbon, a cubic centimeter of which has a high resistance as compared with the resistance of a cube of dense gas, or unplated arc-light carbon of the same size. "Compared with" means considerably higher, so that the difference may be expressed by a ratio rather than by an absolute difference. V., 3769.

A carbon burner has a high specific resistance when its resistance is high compared with what it would be if it were made of dense gas, or unplated arc light carbon. V., 3768-9.

Carbons of defendant's lamp have a high specific resistance, as compared with dense and unplated arc-light carbons. V., 3769.

The specific resistance of Edison burners is reduced about 20% by their electrical heating while being exhausted. V., 3773.

High specific resistance is due to the fact that the burner is to be shaped before carbonization, because the shaping necessitates the employment of those materials which will become of high specific resistance when carbonized. V., 3794.

High specific resistance does not depend upon the size of the burner. V., 3796.

RESISTANCE, SPECIFIC—(*Continued*):

At the date of the patent in suit there was no information extant as to the specific resistance of an incandescent carbon burner, or as to its physical properties when enclosed in a highly exhausted air-tight chamber: hence it was impossible to mathematically determine the size necessary to be given to it to make it practicable. V., 3590.

As far as Mr. Edison's invention was the outcome of any discovery, it was the discovery that a carbon burner, even when small in diameter and of high specific resistance, would be practically stable when enclosed in a globe from which all gases were excluded. V., 3683.

Patent in suit describes making a lamp with carbon burner of high specific and high total resistance. V., 3766.

Do not know of any carbonizable material, which upon being carbonized will not yield a carbon of "high specific resistance," if we except gas carbon, which is the result of carbonizing a material, and from which the burners of some early lamps were made. V., 3797.

Prior to Edison's patent, tests had been made as to the effect of different degrees of heat on the conductivity of carbon, but only within narrow limits, and not at temperatures which would enable one to determine the conductivity of carbon when incandescent. V., 3831.

SEALING:

Sealing in the King lamp is done by means of mercury. V., 3587.

SHAPING:

High specific resistance of the carbon of Edison's burner is due to the fact that the burner is to be made from material which can be shaped before carbonization. This shaping is described in the specification as a part of the process which is to be carried out in the manufacture of the incandescent lamp. V., 3794-5.

The process of making burners described in the patent in suit, involves the reduction of the material to shape before carbonization. V., 3805.

Gauduin's process contemplated the reduction of suitably selected wood to the definite form the carbon was to have, and its subsequent carbonization. V., 3831.

STABILITY:

Edison discovered the means of preventing the rapid destruction of carbon burners, and first stated in his patent the conditions of rendering them stable. V., 3590.

STABILITY—(*Continued*):

That prior to Edison's discovery of the conditions requisite for making the carbon burners stable, they were considered liable to rapid disintegration, is shown by Fontaine, by Prof. Morton, Bernstein, Du Moncel, "Nature" 1880, Outerbridge's lecture at Franklin Institute, Prof. Elihu Thomson, and Swan. V., 3591-7.

The opinion that incandescent carbon burners were unstable had become so fixed in the minds of scientists, that even when Edison's discovery was made known, they did not recognize in it any advance over prior lamps. Proved by extracts from Du Moncel, Morton and Swan. V., 3592-5.

From what he said in a discussion following Outerbridge's lecture, Prof. Elihu Thomson, in 1880, was evidently not that a carbon filament heated to incandescence in a high vacuum would be stable. V., 3596.

The difference in the power of resisting shocks, concussions, and the high temperature in the Edison 16 candle-power 106-volt lamps and in the thicker filament of the 16 candle-power 61-volt lamps, is not great enough to make much difference in their durability. V., 3651.

Even the densest carbon holds air confined within its pores, which, if allowed to remain, will cause a real burning of carbon. The prior lamps had this defect on account of defective construction of lamp chamber. V., 3660.

In modern lamps there is no leakage, and the little oxygen left would have no effect on the life of the burner. But in the old lamps, there was oxygen left in burners and chambers, and, owing to defective construction of the lamp chamber, oxygen leaked in, with the result of lessening the life of the lamps. V., 3663.

If combustion effected the life of modern incandescent lamps, it would be noticeable by preponderance of the action at some particular point. But the lamps show no such effect, and remain uniform in size and brilliancy until they break. V., 3664.

Edison discovered that carbon heated to incandescence in a vacuum by the passage of an electric current, is stable, even when the carbon is small in diameter and seemingly very fragile. Scientific men did not at first believe the carbon filament would be durable, on account of the destructive action of the heat and current, because they did not know that there would be any virtue in the use of a high vacuum. V., 3668.

While it is not claimed that the carbon in the modern incandescent lamps will last forever, yet, taken in connection with the knowledge prior to the invention, Mr. Edison's discovery, in its effect upon the commercial question of electric lighting, was, practically speaking, the discovery of the stability of carbon. V., 3670.

STABILITY—(*Continued*):

Prior to date of patent in suit Bernstein and Morton ascribed the evaporation of the carbon burners in old lamps to the action of the current and heat, and not to the gas contained in the globe. V., 3672-3673.

Greener and Staite, in 1846, proposed to use a purer carbon to prevent evaporation, and their directions would not have led to the use of a high vacuum for this purpose. V., 3674-5.

In his lecture in 1878, Prof. Morton ascribed the wasting away of the carbon in Konn's lamp to a "sort of evaporation," and did not recognize the true cause. V., 3681.

Stability was not attained in former lamps, even when all gas which would support combustion had been removed. V., 3681.

Edison's invention, so far as it was the outcome of any discovery, was based upon the discovery that a carbon burner, even when small in diameter and of high specific resistance, would be practically stable, when enclosed in a globe from which all gases had been permanently removed. V., 3683.

Mr. Edison made the discovery that a burner of very small diameter, which was quite porous, and hence having high specific resistance, possessed sufficient stability to make it suitable for use as a burner in a practical incandescent lamp, by which the light could be subdivided. V., 3687.

The carbon pencils of the old lamps were large enough to protect them from injury by mechanical shocks, but were useless as regards electrical stability, on account of evaporation. Mr. Edison prevented this evaporation, and thus made the use of both large and small carbon burners available in practical lamps. V., 3689.

Mechanical stability refers to the ability of the carbon burner to withstand mechanical shocks and the effects of the heat and current without breaking. Evaporation does not cause breakage in modern lamps. V., 3691.

Before Edison's discovery, the art considered that the best results as to mechanical stability were to be sought in burners of much greater cross-section than is used in modern incandescent lamps, *i. e.*, by pencils or rods. Du Moncel, from his knowledge of prior lamps, in 1880, held the opinion that the heat of the current would "disaggregate the carbonaceous particles" of all carbon burners, and diminish the mechanical stability of the small and slender burner of the Edison lamp. V., 3693-4.

It is not a natural conclusion that because a burner of a particular diameter has sufficient mechanical stability to render it practically durable, another of smaller diameter would not differ so greatly as to render it impracticable. This would have to be determined under the conditions disclosed by Mr. Edison, though it would be correct to assume that a little difference in diameter would not make so great a difference as to render the latter impracticable. V., 3695.

STABILITY—(*Continued*):

Mechanical stability depends largely upon the nature of the material from which the carbon is made and its subsequent treatment. V., 3696.

If it had been ascertained that the carbon rods of the old lamps, which contained an inert gas, were stable, the art would have assumed that the stability was owing to their size, and would not have been led to construct the filament, thinking it would not be stable enough to be of practical utility. V., 3706.

The art would have supposed, prior to date of the patent in suit, that the stability would diminish in a much greater ratio than the reduction in diameter, and to such an extent as to render quite small burners impracticable. There is a limit as to size beyond which present skill cannot go. V., 3707.

Du Moncel even considered the rod burners of Lodyguine & Kosloff to be of too "small cross-section" to possess the requisite conditions of solidity and stability. V., 3711.

The stability of the burner made according to the patent in suit is not a question of degree, as compared with the old burners, which had practically no durability. The stability of the burner was in the main due to the new condition under which it was operated, *i. e.*, in a very high vacuum. V., 3720.

The patent in suit first instructed the art to electrically heat carbon burners to aid in obtaining a high vacuum, resulting in rendering them practically stable. V., 3782.

In view of the statements in the patent in suit and in the patents of Sawyer & Man, the art would have recognized that the carbon would not be stable, unless the occluded gases were driven out of the burner by electrical heating. V., 3786.

SUBDIVISION:

The literature of the subject shows that subdivison was attempted by means of incandescent lamps many years prior to 1879. V., 3552.

General conception of the term, "subdivision of the electric light" (likewise called "dividing the current," "distribution of the light," etc.), was not limited to dividing one arc lamp into several smaller arc lamps conveniently located, but referred to any kind of electrical lamps, equal in illumination to a gas jet, a considerable number of which might be oper-

SUBDIVISION—(*Continued*):

ated from one generator at reasonable distances from it, and which should be economical, durable, and cheap enough to be commercially useful, and so simple and reliable that they could be placed in the hands of the public to manipulate. V., 3552.

That former inventors had attempted subdivision by means of incandescent lamps, is shown by Fontaine's reference to the lamps of Changy, Lodyguine, King, Jablochkoff, Brush and Edison's platinum lamp: by Prof. S. P. Thompson's lecture in 1878; by Higgs' & Brittle's "Dynamo Electric Apparatus," 1878; by Prof. Morton's lecture in 1878; by the British Parliamentary Report on "Lighting by Electricity" in 1879; by William Trant's article in Nature, 1879; and by Preece's mathematical discussion of the question, and Schwendler's comments on the same. There might be added the interview with Prof. Morton, published in New York "Times," 1879. V., 3552-61.

The invention of the Gramme and Siemens' machines furnished the means for producing electricity in large quantity and economically, but these, in conjunction with the Lodyguine lamp, did not solve the problem of subdivision. V., 3562.

Prior to the filing of application for patent in suit, scientific men almost unanimously considered subdivision impossible: the few who believed it possible were all of opinion that the problem remained to be solved. This is shown by reference to the following authorities: Higgs' Translation of Fontaine's Book on Electric Lighting, 1878; Second Edition of Fontaine's Work, published in Paris, in 1879 (which is remarkable in omitting Chapter on "Divisibility of the Electric Light," which appeared in the first edition of this work); Prof. Morton's "Lecture upon the Electric Light," 1878; Prof. Morton's Report to the Lighthouse Board, 1879 (after date of application for patent in suit): Prof. S. P. Thompson's lecture on "The Electric Light": Preece's Paper; "Engineering," 1879; "Engineer," 1879; Du Moncel, in "Lumière Electrique," 1879; Conrad Cooke, Mr. Preece, Sir Wm. Thomson, before Parliamentary Committee, 1879; Trant, in Nature, 1879; Alexander Bernstein, in a work entitled "Electrische Beleuchtung," 1880. V., 3562-75.

The semi-incandescent principle was at one time a favorite mode of attempting subdivision, but was abandoned about 1881. V., 3568.

Preece in 1879, considering both arc and incandescent lamps, says: "Hence, the subdivision of the light is an absolute *ignis fatuus*." V., 3571.

Theory and experiment led scientific men to believe that the diminution in total amount of light produced, even with few lights in circuit, would be so great as to render subdivision commercially impossible. Electric light systems of to-day furnish practical proof of their error. V., 3575.

SUBDIVISION—(*Continued*):

Prior to the patent in suit, it was maintained that subdivision was impossible, on account of rapid diminution of the light, by Fontaine (see Higgs' Translation, Chap. XI.): Preece, on "Electric Light": S. P. Thompson, in "Engineering," 1878; Higgs, on "The Electric Light in its Practical Application," "Engineering," 1879; "Engineer," 1879; Parliamentary Report on "Electric Lighting," in the testimony of C. W. Siemens and Sir W. Thomson: Du Moncel, in "Lumière Electrique," 1879. V., 3575-3582.

The fallacy underlying the experiments of Fontaine and the conclusions therefrom of scientific men, was in assuming that the smaller lights were to be obtained without change in construction of existing lamps, by delivering a smaller current to each lamp, thus reducing the temperature of the burner and the amount of light emitted by it. V., 3577.

From the references to Thompson, to "Engineer," 1879, Du Moncel, in 1880, and Higgs' Translation of Fontaine's work, it is apparent that, prior to November, 1879, subdivision would have been thought quite advanced, if not wholly accomplished, when a few lamps could be successfully operated on one circuit. The lamps might have been of much less resistance than 100 ohms hot. Durability, simplicity and cheapness, with about the light of a gas jet, were the desiderata. V., 3583-3584.

Commercial development since date of application for the patent in suit has shown that practicable subdivision was not dependent upon having a lamp of as much as 100 ohms resistance hot. V., 3584.

Since 1873 the attention of electricians was very generally directed to the problem of subdivision, and it is frequently mentioned in the literature of the art. V., 3606.

Higgs' statement of the laws of heating effect is true, but the conclusion that the rapid falling off in the amount of light would render subdivision impossible, is not true to-day. It is known to-day how to prevent this rapid falling off. V., 3612.

It is possible to-day to divide the amount of current required by a 16 candle-power lamp among several lamps of less than 16 candles, so as to produce the same total amount of light as would have been obtained if the whole current had been sent through the 16 candle-power lamp. This was generally conceded to be impossible when Higg's book was written. V., 3613.

We know to-day how to divide the amount of current required by one 16 candle-power lamp, constructed in one manner, among several 16 candle-power lamps, constructed in another, and suitable, manner. This ability to increase the number of lamps and the total amount of light

SUBDIVISION—(*Continued*):

with a small current, is a valuable feature of modern incandescent lighting, as it saves much in the cost of conductors. V., 3613.

Prior to the patent in suit attempts were made to divide the current among several lamps of like construction, with burners of large diameter and low resistance, but to-day we make the subdivision by means of burners of smaller diameter, less surface, and higher resistance, and are able to use conductors of smaller size and less cost. V., 3614.

The art of subdividing the current has to-day reached a point where progress is exceedingly slow, the Edison 16 candle-power lamp being as small in diameter as is consistent with other requirements. Since the method of subdivision was made known, nothing has been done further, except to improve the durability and economy of the lamps. V., 3615.

The general tenor of his article shows that in Higgs' opinion, subdivision either by arc or incandescent lights was altogether impossible. V., 3619.

Fontaine's book, translated by Higgs, contains experiments supposed to prove that, when the current was divided among three or four incandescent lamps, the falling off in the amount of light was so great as to render subdivision practically impossible. V., 3619.

It was never considered as necessary to subdivision that the number of lamps, or the distance from the source of supply, should be comparable to the numbers of gas-jets from a single gas-works and their distance from the same. V., 3621.

Subdivision would have been practically solved, when fifty lamps were made which could be operated from a single generator, such lamps being about equal to a gas-jet, and also durable, cheap and economical enough to make them commercially practicable, and so simple as not to get out of order, and not requiring large and expensive conductors. V., 3621.

If Edison, in 1879, had only made fifty 100 candle-power lamps according to the method of the patent in suit, and had found that they could be operated from a single source, it would have been regarded as a solution of the problem of subdivision. V., 3622.

Change in resistance of the burner would not alone accomplish subdivision: the length, diameter and surface must be taken into consideration. V., 3625.

In dividing a single burner into several of less power, we should increase the resisttance and decrease the surface of the lesser burners, in order not to increase the size and cost of conductors. V., 3626.

SUBDIVISION—(*Continued*):

At the date of the patent in suit, the theoretical knowledge of electricity extant was sufficient to enable a person to properly proportion a burner, so as to give a desired amount of illumination, but in the absence of a practical incandescent lamp, such ability would hardly have been called into play, or, if it were, it would not have accomplished anything toward subdivision. V., 3627.

If a person had made multiple arc lamps having a power six or ten times that of a gas jet, subdivision would have been accomplished, provided the method of making the lamps would have shown the art how to make, with its prior knowledge, practically commercial lamps of the power of a gas jet, so constructed that a sufficient number of small lamps could be operated in multiple arc, which would give a total amount of light equal to that of the larger ones, the amount of copper in the conductors, the total current, the electro-motive force, and economy being the same in both cases. Lamps of this character had not been made prior to the patent in suit, and in fact not for a considerable time after it was issued. V., 3628.

The invention described in the patent in suit constitutes the practical solution of the subdivision of the electric light, because it describes a method of making a practical commercial electric lamp with a burner possessing characteristics allowing a considerable number of such lamps to be operated in multiple arc on a single circuit. The art without further instructions, would know how to construct such lamps, so that they would have the power of a gas jet, and be suitable for interior lighting. V., 3629.

When the patent in suit described the method of making durable lamps, the problem of subdivision was solved. V., 3631.

Subdivision would have been accomplished by the construction, in accordance with the process of the patent in suit, of a single durable and economical lamp, assuming even that it had been 250 candle-power and only four ohms resistance. V., 3635-6.

One of the conditions for the practical subdivision of the electric light is, that the aggregate light given off by the smaller lamps should be produced at the same cost as an equal amount of light developed at a single focus. V., 3638.

In the Edison French patent for his platinum lamp he suggested that subdivision was to be attained by burners of high resistance and small diameter. V., 3702.

The knowledge that the electro-motive force must be increased in proportionl to the number of lamps if they are connected in series was not essentia

SUBDIVISION—(*Continued*):

to subdivision, as this was accomplished, not by lamps in series, but in multiple arc, in which the electro-motive force does not increase with the number of lamps but remains constant. V., 3725-6.

The reason for claiming that subdivision was accomplished by lamps arranged in multiple arc, is that after the invention described in the patent in suit, Mr. Edison, and others, first made such lamps for use in multiple arc, and the greater part by far of incandescent lighting is done to-day by lamps in multiple arc. It was only after lighting by multiple-arc arrangement came into extensive use that lighting by incandescent lamps in series was taken up, and the amount of lighting with incandescent lamps thus arranged is limited: hardly five per cent. of all lamps in use are series lamps. V., 3731.

In April 1879, a person skilled in the art, starting out to substitute carbon for platinum in an incandescent lamp, would have tried carbon rods like those used in prior lamps, and meeting with failure, would never have gone far enough to even consider the question of adapting the burners to use in multiple arc or in series. Fontaine, in attempting to subdivide the electric light, made experiments with lamps in multiple arc and in series, but used the *same* lamps in each case, not attempting to adapt the resistance of the lamps to the conditions under which they were arranged in circuit. The art would not have known in April, 1879, that the burners would have to be shaped differently to adapt them for use in multiple arc and series. V., 3816.

After careful consideration of the circumstances under which I was led to take the position in x-Qs. 56-90, 217, 328 and 362, perhaps elsewhere, I am convinced that that it was not a proper one, and I desire to change it. The assumption upon which it was founded, namely, that the durability of carbon burners was first ascertained for those of large size and high illuminating power, was, as I have often stated heretofore, contrary to the history of the development of the art, or what I believe would have been possible, the discovery having been actually made with respect to small burners of low illuminating power, which directly solved the problem of subdivision. If the stability of carbon had been discovered for carbon rods, this would have been a great advance in the art of electrical lighting; but whether the art, admitting the desirability of subdivision, would have continued for a time to use lamps having rod burners, not recognizing anything in their construction adapted to the making of small lamps, and whether, in view of all the facts relating to the state of the art as it might thus exist, a person would have arrived at the small lamp without invention I am unable to say. V., 3852-3.

UTILITY:

The lamp described in the Sawyer-Man patents was of no practical value for commercial purposes. V., 3781.

UTILITY—(*Continued*):

The construction by Edison of a lamp which made it possible to take advantage of the stability of carbon in a high vacuum and to use a burner of filamentary form, which made incandescent lighting commercially possible, was an invention of great merit and utility. V., 3590.

VACUUM:

Vacuum in King's & Roberts's lamps would have been very imperfect, even if it were the best then obtainable. V., 3586.

That the patent in suit makes no mention of prior carbon lamps in which vacuum is used, is quite immaterial, since the lamps giving most promise used inert gas in the lamp chambers. V., 3587.

Prior inventors, as shown by the construction of their lamps, did not contemplate using, nor deem essential, the almost perfect vacuum mentioned in Edison's patent. V., 3588.

Poor vacuum in prior lamps would have caused so great loss of heat, that impracticably large leading-in wires, incapable of being sealed in by fusion, would have been required, in order to conduct the increased current necessary to maintain the burner at normal heat and incandescence. V., 3588-9.

The lamp chamber in De Changy's platinum wire lamp was not intended to be air-tight. V., 3600.

King and Roberts only removed the air from their lamp chamber for the purpose of preventing the oxygen from consuming the carbon. A high vacuum would not have been attained in Roberts' lamp by using a Sprengel pump, because his lamp chamber leaked. V., 3667.

The impossibility of stopping the leakage of the old lamp chambers, led to the abandonment of the use of a vacuum and the substitution of a gas that would not consume the carbon, and would keep the air out. V., 3667.

Several scientific men pronounced Edison's invention a failure, because they did not understand the effect of a high vacuum upon the stability of carbon. V., 3668.

The suggestion that an air-tight vessel was to be used by Greener and Staite would not have produced a better lamp than Roberts', nor have led to the discovery that evaporation of carbon could be prevented by using a high vacuum. V., 3674-5.

The suggestion of an air-tight vessel in Greener & Staite's patent means simply that oxygen is to be removed. V., 3677.

VACUUM—(*Continued*):

It was not until after the date of the patent in suit that it was ascertained that burners enclosed in a high vacuum would have sufficient mechanical stability to resist the effect of the current and heat, irrespective of their diameters. After Edison had discovered this for some sizes of carbons, the art had means by which it ascertained that all other sizes used in modern lamps have this same stability. V., 3691.

Prior to patent in suit the art did not know that there was an advantage in enclosing a carbon pencil in a very high vacuum, and was not in possession of a lamp chamber, by means of which the experiment could be tried. V., 3701.

The stability of the burner described in the patent in suit was in the main dependent upon the new condition under which it was operated, *i. e.*, in a very high vacuum. A "very high vacuum," is a vacuum so high that the lamp shall be durable enough to make it of commercial value. V., 3720.

In too low a vacuum, lack of durability and efficiency, taken together, prevent the lamp having any practical value. Having the lowest vacuum that will give a practically durable carbon, durability and efficiency increase up to the highest vacuum practically attainable, but not in a degree corresponding to the perfection of vacuum. V., 3720-1.

Large burners admit of the use of a lower vacuum than the small burners, because the low vacuum carries away the heat, and necessitates an increase in current, to keep the burner up to its proper temperature and candle-power, and this can be withstood better by the large than by the small burner. V., 3721.

Since the date of the patent in suit it has been ascertained that, by diminishing the vacuum to a certain extent, a burner which in a high vacuum was commerially durable, may be impaired and even destroyed. V., 3723.

The vacuum used in the lamps of Edison Company is $\frac{1}{30000}$ of an atmosphere. A Torricellian vacuum may be as high as this. V., 3723.

The means for obtaining a high vacuum in barometer tubes has been known for many years. The vacuum obtained by the common air pump would be very low as compared with the vacuum in the barometer tubes obtained by the Torricellian method. V., 3724.

Electrical treatment of the lamps while being exhausted, was a well-known means of obtaining a high vacuum, and would be naturally employed by the art in following out the directions of the patent to obtain a very high vacuum. V., 3775.

The directions given in the patent in suit, taken in conjunction with the patents of Sawyer-Man, were sufficient to instruct the art to employ elec-

VACUUM—(*Continued*):

trical heating during exhaustion, to aid the pump in perfecting the vacuum. V., 3780.

The patents of Sawyer-Man do not contain any statement that electrical heating is for the purpose of securing a high vacuum. V., 3780.

If the globe is exhausted without heating the burner, the vacuum is so low that the burner is soon destroyed; while, on the other hand, the vacuum obtainable with electrical heating is so high that the burner is durable. V., 3787-8.

With electrical heating a vacuum could be obtained as high as that mentioned in the patent in suit; without electrical heating it would not be half as high, assuming the carbon burner to be of filamentary size. V., 3788.

The vacuum in which a carbon burner is practically durable is high enough to be properly called a "high vacuum;" while a vacuum in which the carbon will not be durable is properly called a "low vacuum," in the sense that it is so low as to prevent the carbon being durable. V., 3791.

Facts have come to my notice concerning tests which have been made which convince me that I have been in error heretofore as to the absolute necessity of electrically heating the burner during exhaustion, in order to obtain a lamp which would have been durable enough for practical purposes at the date of the patent in suit. I am now convinced that electrical heating would not have been necessary with a lamp like that described in said patent, having a carbon burner of small mass and not having large metallic parts enclosed in the glass chamber, although good skill and judgment would, in view of the prior state of the art and the instruction contained in the patent, have suggested the use of this method in order to obtain the best possible lamp. V., 3851.

COOKE, Conrad W.:

states that he is a member of the Society of Telegraph Engineers, and of the Physical Society of London; that he was formerly a partner in the firm of Whieldon & Cooke, electrical and general engineers; that he has given special attention to the progress of electric lighting and contributed to the literature upon the subject, particularly in the journal called "Engineering," in which are twenty or thirty descriptions of all the systems, and I think they have all, with one or two exceptions, been written by myself" (Testimony before the Parliamentary Committee on Lighting by Electricity, April 29, 1879). VI., 4112-3.

SUBDIVISION:

States that incandescent lighting might be applicable in cases where economy is not an object, and where there is some special reason for dividing the light; that the lighting of large areas by the electric light can be done satisfactory and without excessive cost, but that, in the present state of the art, this is not true for domestic illumination.

The light should be centralized rather than subdivided. It is very desirable that the lights should be distributed in a great many places, but when the current is divided a certain amount is lost at each point of division. The fact that the light cannot be divided is one great difficulty in its use for street lighting, and the insufferable difficulty at present as regards domestic illumination. As to Mr. Edison having subdivided the light: "A few newspaper paragraphs have appeared on the subject, and I have been very much interested, as everybody has. His nephew told me, himself, that he has seen, I think, over 200 lights in one circuit. I must say I should like to see it myself, and that is all I can say" (Testimony before the Parliamentary Committee on Lighting by Electricity, May 2, 1879). VI., 4114.

CROSS, Prof. Charles R.

ART, HISTORY OF:

Does not find in any patents or other publications prior to the invention of Sawyer and Man, as described in their Patent No. 317,676, any suggestion of the use of a vegetable fibrous carbon as the burner of an incandescent lamp (McKeesport suit). III., 1835, **7338.**

January 9, 1880, was a very early date in the history of commercial electric lighting (McKeesport suit). III., 1904, **7615.**

BURNER OF CARBON:

Prior to patent in suit, it had been the practice to endeavor to lower the specific resistance of the carbon of incandescent burners. Constructors employed carbon of the same character as that used in arc lighting, as to which strong endeavor had been made to reduce the specific resistance to the lowest practicable limit, and the general use of such carbons in incandescent lamps led of course to a similar lowering of the specific resistance of the carbon burners used in them. Sawyer and Man, in 1878, employed a process of treating a carbon conductor in a hydro-carbon, which largely diminished its specific resistance. Fontaine, in 1877, published a description of various processes of making electric light carbons, from which it appears that the specific resistance of such carbons was reduced in the process of manufacture by soaking in syrups and recarbonizing them. The effect of this was to fill up the pores and make a denser structure of lower specific resistance. This process is particularly set forth in Edison's British Patent No. 3765, of September 16, 1880, wherein he says that the process lessens the resistance of the carbon and increases its liability to disintegrate, and that it is unfit for use in incandescent lamps. III., 1725, **6898-900**; 1727, **6905**, and 1727-8, **6908-10.**

Does not find in patents or publications prior to the invention of Sawyer and Man any description of the use of a burner made of vegetable fibrous carbon, as set forth in their Patent No. 317,676. The collected papers of Sir Humphrey Davy and articles from the "American Journal," "Comptes Rendus" and Watts' "Dictionary of Chemistry," are mere descriptions of scientific experiments, and do not describe or purport to describe electric lamps (McKeesport suit). III., 1835-6, **7338-41.**

The patents of Slater and Watson, Binks, Harrison, Burleigh and Danchell, Le Molt, and Gauduin, relate only to arc light carbons and their preparation, and throw no light on the use of fibrous carbon for incandescent

BURNER OF CARBON—(*Continued*):

lighting. They tend to lead one in the opposite direction. The requi. sites of carbon suitable for arc lighting are the reverse of those demanded for incandescent lighting. Carbons for arc lighting should be exceed. ingly hard and very incombustible, and their resistance should be as low as possible. To accomplish the last result, they are almost universally coated with copper. Incandescent carbons on the contrary should have a high rather than a low resistance (McKeesport suit). III., 1836-7, **7342-6.**

The patents of Pinkus, De Moleyn, Greener and Staite, Shepherd, Way, Konn, Werdermann, and Varley, relate only to semi-incandescent or similar lamps. The necessities for a semi-incandescent or similar lamp are very different from those arising in incandescent lighting, and none of these patents direct one's attention to the use of vegetable fibrous carbon in an incandescent lamp (McKeesport suit). III., 1837-8, **7347-9.**

The patent of Staite, and that of Gardiner and Blossom, relate only to incan- descent lamps with metallic burners (McKeesport suit). III., 1838, **7349.**

The publications which relate to incandescent lamps having carbon burners are the patents of King, Roberts, Konn of 1872, Kosloff, and Jensen, and the publication in "Mechanics' Magazine" which describes King's lamp, and an article in the "Journal of the Society of Arts" upon the Lody- guine lamp. These publications in no way direct one to use a vegetable fibrous carbon. Konn's patent of 1872 is exceedingly indefinite and ambiguous, and calculated to confuse the mind of the reader; but it appears that the patent directs one to use such graphite or gas carbon as was well known in connection with electric lighting, in order to get the full benefit of the invention. There is no intimation in the patent that anything but disadvantage would result from using any other than a graphite carbon, and an electrician by its instructions would have been led away from the use of a fibrous carbon (McKeesport suit). III., 1838-40, **7350-9.**

The article in the "Journal of the Society of Arts" is indefinite, ambiguous and confusing. It contains no scientific description of Lodyguine's lamp. The word "charcoal" is used in referring to the burner, but as used does not denote any kind of fibrous carbon, but rather a hard gas-retort carbon which had for many years been used in arc lighting. This will appear from the contents of the British Patents No. 3809, of 1872, to Konn; No. 91, of 1873, to Konn; No. 441, of 1875, to Kosloff; and No. 970, of 1875, to Jensen (McKeesport suit). III., 1840-3, **7360-70,** and 1838, **7352.**

BURNER OF CARBON—(*Continued*):

Roberts' patent of 1852 is exceedingly indefinite, ambiguous and calculated to confuse the reader, and in referring to the use of "a thin piece of graphite, coke, charcoal or other infusible body," indicates only that some form of carbon is to be employed, and does not at all intimate that vegetable fibrous carbon is to be used (McKeesport suit). III., 1843 4, **7371-3,** and 1838, **7352.**

Even if the word "charcoal" as used in Roberts' patent is to be understood in its popular sense, the other statements in the patent would have led one to use the other more infusible and less destructible forms mentioned therein, and especially graphite (McKeesport suit). III., 1845, **7379.**

Understanding the word "charcoal," as used in Roberts' patent and in the description of Lodyguine's lamp in the "Journal of the Society of Art," to refer to ordinary charcoal, it would not constitute a description of the use of a burner made of the carbonized fibrous material of Sawyer-Man Patent No. 317,676. Such charcoal would be imperfectly carbonized, uneven in structure, and irregular in resistance. In making a burner from such material, it would have to be cut across the fiber, and the burner thus made would have no utility (McKeesport suit). III., 1845-6, **7380-3.**

All commercial lamps made since 1880 have carbon burners, and none of them make use of mineral carbon. The burners of all these lamps are made from fibrous material, excepting in one case where tamadine is used. With this material, however, the cellular structure, which gives fibrous material its peculiar value, is retained. The parchmentizing process, to which the threads used in the Swan and in the Westinghouse lamps are subjected, does not destroy their fibrous character (McKeesport suit). III., 1854-5, **7415-9.**

None of the forms of carbon described in patents and publications prior to 1880, which have been put in evidence by the Edison Company, would be capable of commercial use as burners in incandescent lamps, not even with the various improvements which have been made up to 1889 (McKeesport suit). III., 1862, **7447.**

Fibrous carbon needs a better protection than the hard gas carbon which had been used in incandescent lamps before that of Sawyer and Man, inasmuch as it is more readily destroyed by the action of oxygen (McKeesport suit). III., 1871, **7483.**

Paper has been largely and successfully used as the material from which to make carbon burners (McKeesport suit). III., 1873, **7490.**

Prior to 1880 a person would have known that, in making a burner from a strip, the latter should not be cut anywhere across the fibers, and that to

BURNER OF CARBON—(*Continued*):

do so would make the burner useless. He would have selected material in which the fibers are continuous and which would not be cut or broken in shaping (McKeesport suit). III., 1875-6, **7499-503.**

If small pencils of carbon made by Gauduin's process had been used as incandescent burners, for example, in the Jensen lamp of 1875, they would possess no properties superior to or different from those of the hard gas carbon pencils made for the same purpose (McKeesport suit). III., 1882, **7525.**

There is no evidence that Gauduin carbons of the smallest sizes have ever been used as incandescent burners. Understands that they have been used in semi-incandescent lighting, for which they would be better adapted than for incandescent lighting. This statement is based upon his present knowledge of what should be the character of carbon to make it most suitable for incandescent lighting, rather than upon the knowledge as it existed in 1877. As to these small carbons, there is no doubt that some of the lamps devised about 1877 were intended to employ a burner as large as 1.6 millimetres in diameter and 15 to 18 millimetres in length. Such a burner would not differ radically in size from the proportions given for a small form of lamp on page 99 of Sawyer's book on "Electric Lighting," or from the size of the burner shown in Fig. 3 of Sawyer-Man Patent, No. 317,676. Gets the idea that Gauduin's small carbons were used in semi-incandescent lighting from Higg's translation of Fontaine's book on electric lighting. Gauduin's process is also described in this book, and it likewise contains a reference to the use of Gauduin's carbons in a Konn lamp, and states that they had a diameter of 1.6 millimetres, which is the size of the burners of Sawyer above referred to. Although the Gauduin carbons have been used in incandescent lamps, as just stated, this is no reason why he should not still affirm that Gauduin's process relates only to arc lighting and the making of carbons for this purpose (McKeesport suit). III., 1884-90, **7533-58.**

Does not admit that the process of making a practical incandescent burner was known prior to 1880 (McKeesport suit). III., 1909, **7633-4.**

CARBON:

In the manufacture of carbons by soaking in syrups and recarbonizing them, described by Fontaine in 1877, the result is to fill up the pores and make a denser structure of lower specific resistance. III., 1727, **6907.**

Gas retort carbon had been used for many years in arc lighting prior to 1873 (McKeesport suit). III., 1841, **7263.**

All commercial lamps made since 1880 have carbon burners. In no case is mineral carbon made use of (McKeesport suit). III., 1854, **7415.**

CARBON—(*Continued*):

None of the forms of the carbon described in patents and publications prior to 1880, which have been put in evidence by the Edison Company, would be capable of commercial use as burners of incandescent lamps, not even with the various improvements which have been made up to 1889 (McKeesport suit). III., 1862, **7447.**

Fibrous carbon needs a better protection than the hard gas carbon which had been used in incandescent lamps before that of Sawyer and Man, inasmuch as it is more readily destroyed by the action of oxygen (McKeesport suit). III., 1871, **7483.**

The process which Gauduin describes is adapted, and professes to be adapted, to produce a hard and compact carbon, such as was suited to arc lighting. The aim of Gauduin's patent was to make pencils possessing the characteristics of gas carbon, an end which the other inventors prior to Gauduin had also sought to obtain (McKeesport suit). III., 1881-2, **7521-3.**

Thinks that Gauduin's deposited carbon would not be more hard, dense and compact than that deposited by the Sawyer-Man process (McKeesport suit). III., 1900, **7598.**

The endeavor of the Gauduin patent was to produce a carbon equally hard throughout. The result of the process would most likely be an impracticable burner (McKeesport suit). 1912-3, **7648-9.**

CARBONIZATION:

The Sawyer-Man patent gives no special description of a method of carbonizing the fibrous material out of which the burners were made. This would have been unnecessary because the methods whereby thorough, uniform, and complete carbonization could be secured were perfectly well known (McKeesport suit). III., 1874, **7495-6.**

Methods of carbonization in retorts in powdered carbon referred to in the Sawyer-Man patent, were known and had been used in the art of electric lighting prior to 1880 (McKeesport suit). III., 1880, **7519.**

Processes of carbonization applicable to the making of burners were described by Violette and by Sidot prior to 1880. The subject was also well understood by scientific men (McKeesport suit). III., 1909-11, **7635-42.**

CENTRAL STATION LIGHTING:

As in the distribution of gas, many thousands of burners are supplied from a single main, so, also, in the central station system of lighting, many thousands of incandescent lamps, when arranged in multiple arc, can be and practically are supplied over a single circuit. III., 1729-30, **6916-8.**

CLAMPS:

The use of (mechanical) clamps had been customary prior to date of patent in suit. III., 1739, **6956.**

CROOKES'S RADIOMETER:

was not intended by Crookes to be used for illuminating purposes, but for the purpose of subjecting certain objects to the influence of light. III., 1808, **7331.**

DISTRIBUTION OF ELECTRICITY:

In the transformer system, the number of lamps that are fed (in multiple arc) from a single transformer is usually not more than 40 or 80. A large number of these transformers may be, and in practice are, actuated by the current from a single dynamo in the central station. Each transformer is a separate generator of current which feeds only the small number of lamps connected with it. III., 1803-4, **7211-3.**

Admits that he testified in a suit against the Gaulard & Gibbs Patent of 1886, granted for a converter system of electrical lighting. This is one form of the transformer system, although not the one in practical use now. The broad features of this patent are used to-day. They consist in a transformer through whose primary coil an alternating current passes, thereby generating a current of lower electro-motive force in the secondary coil, to which lamps are connected. Does not recollect whether he testified that this system in all essential features was known in 1878. Does recollect having said that induction coils for lowering the electro-motive force were then known, and that there was no novelty in combining an alternating current with such an induction coil or transformer. III., 1914-5, **7655-60.**

FILAMENT:

To say that the term "filament," in the first claim of patent in suit, signifies a burner having a resistance sufficiently high to enable the lamp to be used in simple multiple arc in large numbers in central station lighting, is not philosophical nor tenable. III., 1741, **6962.**

To define the "filament" of second claim of patent in suit as being a burner of such high total resistance (due to the combined factors of specific resistance, area of cross-section and length) that the lamp can be used in large numbers in multiple arc distribution in *competition with other illuminants*, would be entirely vague and untenable. The resistance of such a burner would have to vary with the many commercial factors which would affect and continually change the cost of the light. III., 1753, **7010-2.**

FILAMENT OF CARBON:

Referring to patent in suit, Prof. Cross says: * * * "Mr. Edison here describes for the first time (if I am right) a process by which a carbon *filament* can be made practically" (Letter to Mr. Betts of June 23, 1881). VI., 4385.

A filament like that used in the Edison lamp in evidence would, even if straight, readily bend without breaking under changes of temperature. If straight, it could not be placed in that particular lamp globe (McKeesport suit). III., 1894, **7575**, and 1895, **7577.**

FIRST CLAIM OF PATENT IN SUIT:

Agrees with Prof. Barker that the term "carbon of high resistance" refers to carbon of high *specific*, rather than a carbon burner of high *total* resistance. Is confirmed in this opinion by the statement in patent in suit that "the attempts of previous persons have been to reduce the resistance of the carbon rod," which is correct as regards specific resistance. Furthermore, in speaking of efforts of prior inventors, the patent states that, "I have reversed this practice," which is intended to contrast the invention of the patent with former inventions in the matter of specific resistance, as well as in other particulars. The specific resistance, in in order to be high within the meaning of the claim, must be notably higher than that of previous carbons, so as to produce a material difference in the action of the carbon when in use. III., 1733-4, **6930-4.**

To say that the term "filament" signifies a burner having a resistance sufficiently high to enable the lamp to be used in simple multiple arc in large numbers in central station lighting is not philosophical nor tenable. III., 1741, **6962.**

GASES:

Fibrous carbon needs a better protection than the hard gas carbon which had been used in incandescent lamps before that of Sawyer and Man, inasmuch as it is more readily destroyed by the action of oxygen (McKeesport suit). III., 1871, **7483.**

HEATING DURING EXHAUSTION:

The process of tempering carbon by heating is described in Sawyer-Man Patent No. 210,809, of December 10, 1878. A fibrous carbon, owing to its porous cellular structure, is more susceptible to this treatment than carbons which were used prior to 1880, because the structure allows of the ready expulsion of gases from the whole interior of the filament. Since 1880 the process of heating the burners to a high temperature has been followed (McKeesport suit). III., 1859-60, **7436-40.**

Note—The process referred to, as described in the Sawyer-Man patent, consists in highly heating the burner while surrounded by nitrogen gas.

HYDRO-CARBON TREATMENT:

Sawyer and Man in 1878 employed a process of treating a carbon conductor in a hydro-carbon which largely diminished its specific resistance. Ill., 1727, **6905.**

All manufacturers, excepting the Edison Company, have found it necessary to reduce the porosity of their carbons by the hydro-carbon treatment, even although it lowers the specific resistance very considerably. Ill., 1783, **7131.**

The hydro-carbon process of treating carbon burners was well known prior to 1880, and is described in Sawyer-Man Patent No. 211,262, of January 7, 1879. A fibrous carbon, owing to its porous cellular structure, is more susceptible to this treatment because the deposit of carbon can take place throughout the mass rather than in the form of a superficial coating. Since 1880 this process has been employed, with few exceptions, (not by the Edison Company) to get uniformity of resistance throughout the mass of the filament, and to obtain a standard total resistance, thus healing the defects incident to manufacture of the filament (McKeesport suit). 1859-61. **7436-42.**

As practically used, this treatment is intended to remedy defects in the natural fiber, but not to supersede it. The filaments in practice are not subjected to the treatment to such an extent as to destroy or render useless their original structure (McKeesport suit). Ill., 1861-2, **7444 6.**

described in Sawyer-Man patent may be carried to such an extent that the deposited carbon will be thick enough to form a burner of itself. This carbon is dense if deposited with sufficient thickness. Thinks its specific resistance would be lower than that of fibrous carbon. This deposited carbon is *per se* neither fibrous or textile (McKeesport suit). 1895-6, **7578-82.**

Thinks that Gauduin's deposited carbon would not be more dense, hard and compact than that deposited by the Sawyer-Man process (McKeesport suit). Ill., 1900, **7598.**

The aim of this treatment is to equalize the resistance of the carbon burner and to heal imperfections (McKeesport suit). Ill., 1912, **7648.**

KING'S LAMP:

had a Torricellian vacuum, in order to avoid destruction of the carbon burner by its combination with the oxygen of the air. Ill., 1715, **6859.**

LAMP ARC:

Method of operation explained. Ill., 1714, **6856.**

LAMP ARC—(*Continued*):

The arc lamp was first employed for special purposes about 1845. After 1845 it was used to some extent in lighthouses: after 1873, it was employed more or less in lighting dockyards. About 1876 or 1877 it began to be used for street lighting, for which it has been extensively used from 1878 onwards. Does not recall any instance of its industrial uses prior to 1853 McKeesport suit). Ill., 1882-3, **7527-32.**

LAMP CHAMBER:

The chamber of the Sawyer-Man lamp, as a protection against leakage, is imperfect: and, no doubt, some other form would be preferable for general use (McKeesport suit). Ill., 1886, **7462-3.**

In expressing the opinion that the glass plate and glass stopper of the Sawyer-Man lamp were entirely novel, he had in mind that these devices were old in pneumatic apparatus, but did not consider this use of them had any material bearing upon their use in an electric lamp (McKeesport suit). Ill., 1903, **7610.**

As stated by Prof. Houston, in the manufacture of lamps, it is the custom to close the joints by fusion of the glass and not by the use of cement (McKeesport suit). Ill., 1907, **7626-8.**

As stated by Prof. Houston, the chamber of Edison's lamp is made of two parts, which are subsequently fused together, while the chamber of the lamp of Sawyer-Man Patent, No. 205,144, is made of two parts which are fitted together (McKeesport suit). Ill., 1908, **7630.**

LAMP, INCANDESCENT:

Method of operation explained. Ill., 1714, **6855.**

The lamp shown in drawings of Sawyer-Man Patent, No. 317,676, would be of low resistance, and would require a low electro-motive force and strong current. It would not be suited to multiple-arc work. The lamp chamber, as a protection against leakage, is imperfect: and, no doubt, some other form would be preferable for use on a large scale. The lamp could not compete with gas or with modern incandescent lamps. The glass base, or stopper of the lamp, would diminish the liability to leakage as compared with the metallic bases of prior lamps (McKeesport suit). Ill., 1865, **7460-1**; 1866, **7466**; 1866-7, **7464-5** and 1867, **7468.**

As stated by Prof. Houston, the following differences exist between the Edison lamp and that described in Sawyer-Man Patent No. 205,144. The Edison lamp has a high vacuum, as contrasted with the low vacuum of inert gas of the Sawyer-Man lamp. The former has a high resistance, and the latter, a low resistance. The Edison lamp has a chamber made of two parts, which are subsequently fused together, while in the Sawyer-Man chamber the two parts are fitted together. This lamp is presumably of

LAMP INCANDESCENT—(*Continued*):

high candle-power, and more heat is generated than in the case of the Edison lamp, and means are provided to prevent this heat from injuring the gas left in the chamber (McKeesport suit). III., 1907-8. **7628-31.**

The Maxim lamp, which he examined and reported upon to the Edison Company in June, 1881, was like defendants' M lamp in evidence. III., 1961. **7843.**

MULTIPLE ARC:

Arrangement of lamps in multiple arc enables one to put a vastly larger number of lamps in a single circuit than would be possible if the lamps were made to be run in series, or would be possible with arc lamps. It also makes all the lamps of the system independent of each other, as is the case with gas burners. As in the distribution of gas, many thousands of burners are supplied from a single main; so, also, in the central station system of lighting, many thousands of incandescent lamps, when arranged in multiple arc, can be, and practically are, supplied over a single circuit. III., 1729-30. **6916-8.**

In the transformer system, the number of lamps that are fed (in multiple arc) from a single transformer usually is not more than 40 or 80. A large number of these transformers may be, and in practice are, actuated by the current from a single dynamo in the central station. Each transformer is a separate generator of current, which feeds only the small number of lamps connected with it. III., 1803-4. **7211-3.**

The lamp shown in the drawings of Sawyer-Man Patent 317,676, would be of low resistance, and would require a low electro-motive force and a strong current. It would not be suited to multiple arc work (McKeesport suit). III., 1865-6. **7460-1.**

Series lamps were not customarily made and used prior to January 9, 1880, and possibly not for a year or two later. The conditions of electric lighting did not call for them. The above date was a very early one in the history of commercial electric lighting, and at that time lamps were ordinarily used in multiple arc. These lamps had a resistance varying from 20 ohms upwards (McKeesport suit). III., 1904-5. **7615-7.**

PATENT IN SUIT:

In speaking of a Maxim lamp which was sent to him, and in answer to letters and memoranda from Mr. Eaton, Mr. Betts and Mr. Wilbur, in behalf of the Edison Company, Prof. Cross states that this Maxim lamp (made by the United States Company) of 43 ohms is of undoubtedly high resistance as compared with a lamp of 1 to 4 ohms resistance, and "that beyond a doubt it is a high resistance lamp in the sense of the patent (referring to patent in suit), although of less than the lowest resistance specifically mentioned therein, and less than those sent as types of Mr.

PATENT IN SUIT—(*Continued*):

Edison's own lamps, which have respectively between 3 and 4 times and about 6 times the resistance of the U. S. Co.'s lamp. * * * If there are none others of over 4, 6, or 10 ohms, there is no question that 40 ohms, or even 20 ohms, would be a high resistance in the sense of the patent, *i. e.*, the patent in suit" (Letter to Mr. Betts of June 11, 1881). VI., 4380.

After an examination of Sawyer's book on lighting by incandescence, and two volumes of United States Patents sent to him by Mr. Eaton in behalf of the Edison Company, Prof. Cross says that it would appear that prior lamps had a resistance of not over 5 ohms, and generally less than this. He states that the resistance of the Maxim lamp of 40 ohms is certainly high as compared with a lamp of 5 ohms resistance. The further statement is made that, in spite of the fact that 100 ohms is the lowest resistance for Edison's lamp which is mentioned in the patent in suit, "Mr. Edison here describes for the first time (if I am right) a process by which a carbon *filament* can be made practically. No carbon *rod*, of say 20 ohms resistance upward, could readily be made to emit light by incandescence by any current that could be practically and economically employed. At least this I should judge to be the case. Hence, is not Mr. Edison justified in claiming that even 20 ohms would be a high resistance under the terms of his patent. If only 5 ohms as a maximum were used before; if Mr. Edison's process is a new one giving the possibility of making high resistance carbons, it seems to me that even though the ratio of 5 to 20 ohms is the same as 20 to 100, the claim can readily be held." After reading the British incandescent light patents of De Moleyn of 1841, King of 1845, Staite of 1848, Shepard, of 1850, Roberts, of 1852, Konn, of 1872, Kosloff, of 1875, Konn, of 1875, and Werdermann, of 1878, Prof. Cross states that he still holds the above opinion (Letters to Mr. Betts of June 23-24, 1881). VI., 4384-5 and 4387.

RESISTANCE:

says that it appears that incandescent carbon lamps, made prior to date of patent in suit, had a resistance of not over 5 ohms, and generally less than this (Letter to Mr. Betts of June 23, 1881). VI., 4384.

Facility for shaping carries with it the ability to predetermine approximately the resistance which the burner will have after carbonization (McKeesport suit). III., 1858. **7430.**

The lamp shown in the drawings of Sawyer-Man Patent No. 317,676, would be of low resistance, and would require a low electro-motive force and a strong current. It would not be suited to multiple arc work (McKeesport suit). III., 1865-6. **7460-1.**

The use of incandescent lamps in multiple arc was the first to be developed in commercial lighting. These lamps varied in resistance from 20 ohms upwards (McKeesport suit). III., 1904-5. **7616-7.**

RESISTANCE—(*Continued*):

As stated by Prof. Houston, the Edison lamp has a high resistance, while the lamp of Sawyer-Man Patent No. 205,144, is of low resistance (McKeesport suit). III., 1908. **7630.**

RESISTANCE, SPECIFIC:

Prior to patent in suit, it had been the practice to endeavor to lower the specific resistance of the carbon of incandescent burners. Constructors employed carbon of the same character as that used in arc lighting, as to which strong endeavor had been made to reduce the specific resistance to the lowest practicable limit, and the general use of such carbons in incandescent lamps led, of course, to a similar lowering of the specific resistance of the carbon burners used in them. Sawyer and Man, in 1878, employed a process of treating a carbon conductor in a hydro-carbon, which largely diminished its specific resistance. Fontaine, in 1877, published a description of various processes of making electric light carbons, from which it appears that the specific resistance of such carbons was reduced in the process of manufacture by soaking in syrups and recarbonizing them. The effect of this was to fill up the pores and make a denser structure of lower specific resistance. This process is particularly set forth in Edison's British Patent No. 3765, of September 16, 1880, wherein he says that the process lessens the resistance of the carbon and increases its liability to disintegrate, and that it is unfit for use in incandescent lamps. III., 1725, **6898-900**; 1727, **6905**, and 1727-8, **6908-10.**

Agrees with Prof. Barker that the term "carbon of high resistance" in first claim of patent in suit, refers to carbon of high *specific*, rather than to a carbon burner of high *total* resistance. Is confirmed in this opinion by the statement in patent in suit that "the attempts of previous persons have been to reduce the resistance of the carbon rod," which is correct as regards specific resistance. Furthermore, the patent, in speaking of efforts of prior inventors, states that "I have reversed this practice," which is intended to contrast the invention of the patent with former inventions, in the matter of specific resistance as well as in other particulars. The specific resistance, in order to be high within the meaning of the first claim, must be notably higher than that of previous carbons, so as to produce a material difference in the action of the carbon when in use. III., 1733-4, **6930-4.**

All manufacturers, excepting the Edison Company, have found it necessary to reduce the porosity of their carbons by the hydro-carbon treatment, even although it lowers the specific resistance very considerably (McKeesport suit). III., 1783, **7131.**

The requisites of carbon suitable for arc lighting are the reverse of those demanded for incandescent lighting. Carbons for arc lighting should be exceedingly hard and very indestructible and their resistance should be as low as possible. To accomplish the last result they are almost

RESISTANCE, SPECIFIC—(*Continued*):

universally electro-plated with copper. Incandescent carbons, on the contrary, should have a high rather than a low resistance (McKeesport suit). III., 1836-7, **7344-6.**

High specific resistance is an extremely desirable property in a carbon filament, inasmuch as, for a given current and for a conductor of given length and section, the heating effect is proportional to specific resistance, so that to derive the greatest amount of light from a filament of given size it is desirable that its specific resistance should be high (McKeesport suit). III., 1857, **7427.**

SERIES:

Series lamps were not customarily made and used before January 9, 1880, and possibly not for a year or two later. The conditions of electric lighting at that time did not call for them. The above date was a very early one in the history of commercial electric lighting, and at that time lamps were ordinarily used in multiple arc (McKeesport suit). III., 1904-5, **7615-7.**

SECOND CLAIM OF PATENT IN SUIT:

To define the "filament" of this claim as being a burner of such high total resistance (due to the combined factors of specific resistance, area of cross-section, and length) that the lamp can be used in large numbers in multiple arc distribution in *competition with other illuminants*, would be entirely vague and untenable. The resistance of such a burner would have to vary with the many commercial factors which would affect and continually change the cost of the light. III., 1753, **7010-2.**

SHAPING:

If a burner were shaped out of a piece of charcoal, it would be necessary to cut across the fibers, which would be very undesirable, and such a burner could not be made commercially useful (McKeesport suit). III., 1846, **7382.**

That the material may be shaped before it is carbonized is a most desirable characteristic. Facility for shaping carries with it the ability to predetermine approximately the resistance which the burner will have after carbonization (McKeesport suit). III., 1858, **7430.**

Shaping of the material before carbonizing it is an advantage which cannot be overestimated (McKeesport suit). III., 1868, **7471.**

Prior to 1880 a person would have known that in making a burner from a strip, the latter should not be cut anywhere across the fibers, and that to do so would make the burner useless. He would have selected the material in which the fibers are continuous, and which would not be cut or broken in shaping (McKeesport suit). III., 1875-6, **7499-503.**

CROSS, Prof. Charles R.

STABILITY:

The liability of a carbon burner to fracture from effects of expansion and contraction was recognized in the art prior to 1880 as a defect of straight burners. This defect was alluded to in Kosloff's British Patent No. 441, of 1875, in Jensen's Patent 970, of 1875, and in Sawyer-Man Patent, No. 210,809. These patents describe devices for avoiding the difficulty (McKeesport suit). III., 1850. **7398-9.**

TAMADINE:

is made by dissolving cellulose in a solvent and then precipitating it in a gelatinous state. From this filaments are cut which are afterwards carbonized. This process obliterates the evident, superficial fibrous structure of the material, but permits it to retain that cellular structure which gives to fibrous or textile material its peculiar value for use in incandescent lamps (McKeesport suit). III., 1855, **7418-9.**

VACUUM:

Kings lamp, of 1845, had a Torricellian vacuum, in order to avoid destruction of the carbon burner by its combination with the oxygen of the air. III., 1715, **6859.**

Roberts' lamp, of 1852, had a carbon burner, which his patent states is "enclosed in a vacuum or space not containing any oxygen or other matter which can cause the combustion or destruction of it." The patent further states that "as perfect a vacuum as can conveniently be made" is to be obtained, and that "no combustion will ensue if the vacuum be perfect." III., 1716, **6862.**

As stated by Prof. Houston, the Edison lamp has a high vacuum as contrasted with the lamp of Sawyer-Man Patent No. 205,144, which has a low vacuum of inert gas (McKeesport suit). III., 1908, **7629.**

DU MONCEL, Le Comte Th.

BURNER OF CARBON:

Small needles of retort carbon were used as burners in Lodyguine's lamp ("Some Reflections in Regard to the New Lamp of Mr. Edison," January 1, 1880). VI., 4183.

The burner of the Lodyguine and Kosloff lamp was made from gas carbon of small cross section. It did not possess the requisite conditions of solidity and stability ("Electric Lighting," 1880). V., 3708.

CENTRAL STATION LIGHTING:

After giving a complete account of Edison's system of lighting as exhibited at Paris in 1881, the author, in conclusion, states that "from all this we see Mr. Edison's system to-day is completed, perfectly studied out in all parts, and that nothing remains to be done but to introduce it on a great scale" ("The Electric Incandescent Lamps," October 1, 1881). V., 4335-44.

GEISSLER TUBES:

In describing a Geissler tube made into a form for use in mines, the author states that, on the authority of a mining engineer, "the intensity of the light of this apparatus, which is a little inferior to that of an ordinary safety lamp, becomes equal to it when this latter has burned for several hours, and surpasses it in badly ventilated galleries." He also states that it has been proposed to employ such a lamp for lighting buoys to guide ships in their entrance into port, "but this kind of light is so low in intensity that it appears to us quite difficult to apply it advantageously for this object" ("Treatise on Ruhmkorff's Electrical Induction Apparatus," 1867). IV., 2077-8.

INVENTION INVOLVED:

In commenting upon the Edison carbon lamp, Du Moncel does not recognize wherein any advance has been made in the art. He considers the lamp to be "but a modification of those of Messrs. King, Lodyguine, Bouliguine and Sawyer-Man, &c." He does not appear to recognize that there is any virtue in the filament of porous carbon, or that it is durable in the high vacuum maintained in a globe made of one entire piece of glass, as contrasted with a low vacuum in a lamp chamber made of separable parts, for he states that "it (the lamp) does not even offer the ingenious arrangement of Mr. Konn's lamp, which prevents the extinction of the light in case of the rupture of the incandescent carbon. * * * To-day

INVENTION INVOLVED—(*Continued*):

Mr. Edison takes us backwards, and it is the Lodyguine lamp which he resuscitates under a different form. • • • The receiver in which this system is enclosed is besides void of air like that originally used by Monsieur Lodyguine. It is possible that the arrangement of which we have just spoken may be better than those which have preceded it, but assuredly it does not constitute an invention of the standard spoken of in the American papers. • • • It is besides difficult to admit that this horseshoe of charcoal, so slender and so delicate, does not deteriorate by a prolonged incandescence. • • • The author says, in conclusion, that "I think that the preceding is sufficient for the public to be on its guard against the pompous announcements which come to us from the new world" ("Some Reflections in Regard to the New Lamp of Mr. Edison," January 1, 1880). VI., 4183-6.

STABILITY:

Concerning the Edison carbon lamp described in the "New York Herald" for December 21, 1879, Du Moncel says: "It is besides difficult to admit that this horseshoe of charcoal, so slender and so delicate, does not deteriorate by a prolonged incandescence, for besides the calorific action which tends to disaggregate the carbonaceous particles, a mechanical action of the current is produced which tends to carry them off and deposit them on the sides of the receiver, as is noticed in the tubes of Geissler" ("Some Reflections in Regard to the New Lamp of Mr. Edison," January 1, 1880.) VI., 4184.

While Edison's light was on exhibition in 1881, at the Paris Electrical Exhibition, Du Moncel, after referring to the De Changy platinum lamp and Edison's fruitless efforts in the same direction, says that the use of carbon was suggested "• • • and different arrangements of apparatus were put together at various times by King, Lodyguine, Bouliguine, Swan, Sawyer, &c., some avoiding combustion by enclosing the lamps in receptacles where a vacuum had been obtained, others by filling these receptacles with gases unfit for combustion, as nitrogen or oxide of carbon (carbonic acid gas), or simply by leaving the air shut up in the receptacle to be vitiated by an incipient combustion. All these attempts had but partially succeeded, to say nothing more, when, in 1879, the new incandescent carbon lamp of Mr. Edison was announced, and many *savants*, and myself in particular, doubted the exactness of the allegations which came to us from America. The carbonized paper horseshoe appeared incapable of resisting mechanical shocks, and of supporting incandescence for any length of time. At this epoch Mr. Swan himself said that up to that time he had not been able to obtain any very satisfactory results by an analogous disposition of the incandescent organ" ("The Electric Incandescent Lamps," October 1, 1881). VI., 4333-4.

"Of the different systems employed for obtaining luminous effects by the diminution of the cross-section of a good conductor, that made by

STABILITY—(*Continued*):

Messrs. Lodyguine and Kosloff has given the most interesting results. These results, in 1874, also attracted much attention because the effects were somewhat comparable to those of which we have just spoken (the author here refers to the Jablochkoff candle): but in order to produce them a much greater electrical force was required, and the burners raised from a red to a white heat, which were made from gas-carbon of small cross-section, did not possess the requisite conditions of solidity and stability" ("Electric Lighting," published in 1880, evidently before he had knowledge of Edison's carbon lamp). V., 3708.

SUBDIVISION:

"The peculiar character of the electric light is a power of concentration so great that in a single light one can obtain a brightness surpassing that of two thousand Carcel burners. This property, which may be extremely useful and important in certain applications, notably for the illumination of lighthouses and ships, is evidently a disadvantage from the point of view of public lighting, and the means have long been sought for dividing this brightness between several luminous centres, not only to weaken it to the sight, but also in order to illuminate a larger extent. Unfortunately, the processes of division tried hitherto have solved this problem only at the price of a great loss in the intensity of the light which could be produced at a single focus." After speaking of the Jablochkoff candle, its cost, and application to street lighting, the author says: "It is from now on certain that a completer study of the division of the light cannot fail to lead to more satisfactory results than those which are known to-day." From data given by Preece, relating to the great increase in the illuminating power of an incandescent platinum wire as its temperature is raised by increasing the current, Du Moncel concludes that, "This explains why the division of the light is effected with great loss, for, from each diminution of the current arising from this division, there results a loss of light which might, under certain conditions, reach the 11th power of the ratio in which the current has become weakened." After speaking of the Werdermann semi-incandescent lamp, by which the great force of light, which is stated to be so prejudicial to the Jablochkoff candles, can be avoided, the author says that, "Under the present condition, electric lighting might thus perhaps be employed with a certain advantage; and this advantage might gain in importance if it is considered that, applied to the illumination of a small room, it would avoid the great production of heat which the gas would furnish in the same situation." In conclusion, Du Moncel says: "We, therefore, believe that, if the solution of the problem of electric lighting is not yet complete, there has been made in recent times, a real progress which, being wisely studied, might lead to wholly satisfactory results" ("Considerations on Public Lighting by Electric Processes," prior to May 15, 1879). VI., 4101-6.

In reference to the Lodyguine lamp, introduced into France and modified by Kosloff, the author says that it was claimed that fifteen of these lamps

4

DU MONCEL, Le Compte Th.

SUBDIVISION—(*Continued*):

could be operated by one dynamo, but that he never saw more than two burning at a time. On account of the poor success of this lamp, Reynier and Werdermann tried the semi-incandescent principle with better success. Mr. Edison, with his carbon lamp, takes a step backward, and only resuscitates the Lodyguine lamp in another form ("Some Reflections in Regard to the New Lamp of Mr. Edison," January 1, 1880). VI., 4183.

The Edison system of lighting was exhibited at the Paris Electrical Exhibition of 1881. Du Moncel at that time took occasion to say, in reference to incandescent lighting, that, "in a preceding article, we have shown in what cases this system of electric lighting was especially applicable, and we have seen that now, thanks to the important improvements which have been lately made in it, it can be employed for the lighting of low intensity in the interior of houses; we have also seen that several mansions in England have been lighted in this manner, and that a certain number of houses in the City of New York have made arrangements with the lighting company of Mr. Edison. Since the appearance of these lamps a large number of systems of the same class have been brought forward by different inventors, and, without mentioning those well known, of Messrs. Edison, Swan, Maxim, Lane-Fox, Sawyer, we know of a lot of inventions which relate more or less directly to it. * * * It should, in fact, be remembered that the luminous power of an incandescent body increases in a much more rapid ratio than the heat intensity. Now, for this reason, although incandescent lamps permit of a larger division of the electric light, there must be a loss by the feebleness of the radiant power which results from it. Nevertheless, the satisfactory results which have of late been obtained oblige us to review these systems of lighting, and we will commence, naturally, with that of Mr. Edison, which is the best known, and which has attracted attention to this method of producing lighting by electricity" ("The Electric Incandescent Lamps," October 1, 1881). VI., 4332-3.

EATON, Sherburne, B.:

Was vice-president and principal executive officer of Edison Company from January 11th, 1881, to October 25th, 1882. Was president from October 25th, 1882, to October 30th, 1884. Since October 30, 1884, has been, and still is, general counsel of the company.

BULLETINS OF EDISON COMPANY:

In report to the stockholders in 1883, it is stated: "The bringing of suits against infringers of the Edison patents is a subject which has frequently occupied our attention during the year. * * * Formal notices of infringement, in order to fully preserve our legal rights, have been served upon the various electric light companies that are clearly and undoubtedly infringing, but no suits for infringement have thus far been begun, nobody, as yet, having injured us enough to make it worth our while to go to the trouble and great expense of suit." V., 3858.

Circular issued by the Edison Company, in August, 1886, showed that the company had in operation fifty-eight central station plants. V., 3860.

Bulletins 1-22, issued by the Edison Electric Light Co., were issued originally for circulation among the agents of the company, but later on the circulation was extended so as to include stockholders and others interested in the operations of the company. The statements as to the progress of the business are substantially correct. The paper put in evidence by defendant entitled "Swan Lamp Patents," was prepared by Major Wilber, at that time solicitor of patents for the company, and the statements contained in it are entirely his own personal views. Bulletin 21 is composed of several papers, each of considerable length, taken from different sources, and is different in this respect from the other bulletins published by me, which contain carefully edited matter reduced to short paragraphs, and taken from various sources, such matter being of interest to the business. V., 3861.

COMMERCIAL SUCCESS:

The Edison Company in August, 1886, had in operation fifty-eight central station plants. V., 3860.

COMPETITION WITH INFRINGING COMPANIES:

In 1881 and 1882, the ferryboats of the Pennsylvania Railroad Company were a good advertisement. We should rather have had them than not, but our principal grievance was that the road, without adequate business cause,

COMPETITION WITH INFRINGING COMPANIES—(*Continued*):

had selected some other lamp than Mr. Edison's, notwithstanding the friendly relations of Mr. Edison with the road and its officers. V., 3872-3.

When the installation on their first ferryboat was first made, we had the running of the plant watched, and the fact of the poor running of the plant was used by us with the Pennsylvania Railroad officials to try to induce them to take the Edison lamp. It would not have been difficult for us at that time to install a successful running plant on the ferryboat in question. V., 3873.

We had a plant in the New York Post-Office in 1882, and we regarded it as a good advertisement. Do not remember why it was discontinued, but do not think it was on its demerits. These small plants had really no commercial value, and the profits were not worth considering. We knew that we were first in the field; that the field was vast, and that our energies should be devoted to covering the ground with the utmost possible rapidity. The cost of a plant is one thing, and the profit made on it another. In those days, when few people had confidence in electric lighting, and when we had to get it introduced in conspicuous places on the best terms we could, we installed plants in desirable situations for other considerations than that of money. We had a large capital invested in our business; our stock was selling at a high price, and our entire energy was bent on the rapid development of our business, so that we might at an early day return profits to our stockholders. While we did not regard the United States Company as competitors in a business sense, they were good advertisers, and had influence and capital. They made it a point to secure and run installations at any price, even at a loss, for the purpose of advertising. Their total business was so small that we gave the matter no serious consideration, except at conspicuous points where advertising was a desideratum. It was at those points that they principally attacked us—notably post-offices. V., 3874-5.

In some cases purchasers were influenced by other than business considerations. If a customer considered he was getting a better article from the United States Company than from the Edison Company, it is fair to assume that he did not know what he was doing. V., 3876.

We did not succeed, in 1882, in getting the contract to light the Capitol at Albany, and could not understand why, on business principles, we failed to get it. As an advertisement we put in a plant there to run in competition with some other plant there at the same time. V., 3876.

In a circular prepared by me, in 1883, the first sentence is, "The following list of decrepit Maxim plants is believed to be absolutely correct." The circular shows that there were Maxim plants then installed in manufacturing establishments in New England, and it shows that some of them were decrepit. The main reason for not bringing suit was that they were not serious competitors. V., 3877.

FILAMENT OF CARBON:

We took advantage of the French suit to get before the public a statement to the effect that our principal patents, and notably our filament patent, controlled incandescent lamps. We always made a feature and a prominent one of the filament patent. V., 3869.

INFRINGEMENT:

The report that the Edison Company has obtained an injunction in Paris, France, against the United States Electric Light Company, preventing that company from exhibiting the Maxim lamp at the Paris Electrical Exposition, is true.

We have long been advised by our patent lawyers that Edison's patents gave him exclusive control of incandescent lighting, and that analogous systems were infringements which could be suppressed. Until now, the Edison Company has never taken the trouble to assert its rights. In due time we shall begin other suits in France, and also enforce our rights in this country (Interview published in "New York Tribune," of August 13, 1881). VI., 4400.

Does not understand the reason why the Paris correspondent of the "New York World" has cabled to the effect that the reported stopping of the exhibition of the Maxim Lamp Company, by seizure of its apparatus, or by any other proceedings taken by the Edison Company, is not true. "The rights in the Edison lights for the City of Paris are owned by a syndicate of French bankers. The Edison Company are bound by the terms of the sale to maintain their full rigths, and as there are only three incandescent lights now on exhibition, the Edison, the Swan of England, and the Maxim, and as we claim that the latter two were stolen from us, we began suit against the United States Company in the French courts." Maxim has two kinds of lamps, the arc and incandescent, on exhibition, and perhaps the arc lamps are still being shown, while the incandescent lamps are in possession of the officials of the French courts (Interview published in "New York World" of August 21, 1881). VI., 4401-2.

There is no reason why the Edison Company could not have successfully prosecuted its business, had it remained independent of the Gramme Company. "The Edison Company is devoted exclusively to incandescent lighting, and all other companies composing the Gramme combination are, with a single exception, devoted exclusively to arc lighting. The patents possessed by the arc lighting companies have nothing to do with our business, the two systems of illumination being totally unlike. The company referred to as the exception is the United States Company, which owns the Maxim incandescent light, and I have never heard any one say—not even the Maxim people themselves—that our patents infringe theirs. The real issue between the Edison and Maxim people is that the latter's lamp is a square infringement upon Mr. Edison's." We have never been sued or threatened with a suit by any company. "We are the people to do the suing, as with reference to incandescent lighting

INFRINGEMENT—(*Continued*):

we have exclusive ownership." The Gramme Company "had a monopoly of arc lighting before, and now, that they have got us in they have a monopoly of incandescent lighting as well." "The Gramme Electrical Company will probably settle upon some definite line of policy at the meeting to-day. Notice is given in their circular that all parties manufacturing, selling, using or having in their possession electrical apparatus which infringes the patents of the Gramme Electrical Company will be prosecuted to the fullest extent of the law" (Interview published in the "New York Times" of April 27, 1882). VI., 4406-8.

The fundamental patents which give Edison a monopoly of the incandescent lamp are as follows, namely: No. 238,898, dated January 27, 1880. (Note: This refers to the patent, the number of which is incorrectly stated. It should be 223,898); No. 227,229, dated May 4, 1880 · and No. 230,255, dated July 20, 1880. In these patents the following points are broadly covered by Mr. Edison:

1. An electric lamp having a continuous conductor (without regard to its material, resistance or mode of preparation) and an exhausted glass enclosed globe.
2. An electric lamp having a continuous carbon conductor (irrespective of its material, &c.) and an exhausted enclosed globe.
3. A filament of carbon of high resistance secured by metallic conductors (*i. e.*, the leading in wires).
4. The method of manufacture, *i. e.*, first, separately forming the enclosed globe and the support for the carbon, and then affixing the carbon upon the latter, uniting the globe and support, and then exhausting.

The broad principle covered in the above-named fundamental patents allowed to Mr. Edison is so exclusive that it is not too much to say that neither Swan nor any one else has made or can make a successful incandescent lamp without infringing every one of the above patents" (Interview published in "New York Commercial Advertiser" of August 8, 1882). VI., 4411.

Besides the notices to desist infringing, to which were attached lists of patents, including patent in suit, the officers and agents of the defendant company had frequent notice that the incandescent lamp made by them was claimed to be an infringement of the Edison patents, and especially of the patent in suit. In 1880 and 1881, while vice-president of the Edison Company, I had several interviews with Mr. C. R. Flint, the president of defendant company, and in these interviews the claims of the Edison Co. to possess by its patents a monopoly of the business of making and selling incandescent lamps was a prominent feature of discussion. The patent in suit, known as the "Filament Patent," was always considered as our most important and controlling patent, and in our interviews attention was often called to the infringement of this and other Edison patents by the U. S. Electric Lighting Company. At the time of the Paris Electrical Exhibition, in 1881, a suit for infringement,

INFRINGEMENT—(*Continued*):

based upon the Edison French patent, corresponding to the U. S. filament patent, was brought against the owners of the Maxim incandescent lamp in Paris. That fact that the Maxim lamp was claimed as an infringement of the filament patent was made known by the bringing of the Paris suit and through newspaper publications, both in Europe and this country. Reference is made to an interview with me published in the "New York Tribune," Aug. 13th, 1881, and one in the "New York World," Aug. 21st, 1881. In 1882 a suit was brought upon the English patent corresponding to the U. S. "Filament" patent, against the manufacturers of the Swan incandescent lamp in England. As further showing that claims were made that all incandescent lamps, including the Maxim, infringed the filament patent, the following articles are cited: "New York Times," April 27th, 1882, entitled "Electric Light Monopoly"; "New York Commercial Advertiser," Aug. 8th, 1882, entitled "An Electric Light War"; "New York Commercial Advertiser," Aug. 10th, 1882, entitled "The Electric Light War"; "Paterson Daily Press," Sept. 2d, 1882, entitled "Electricity or Gas"; Davenport, Iowa, "Daily Gazette," May 22d, 1833, entitled "Edison's System." V., 3856-8.

In my report to the stockholders of the Edison Company, in 1883, I stated that the bringing of suits against infringers had occupied our attention during the year, that formal notices had been served upon various companies that were clearly infringing our patents, but that no suits had as yet been brought, because no one had injured us enough to justify the trouble and great expense of suit. We contemplated bringing suit against defendant company as early as 1880, and employed counsel and experts, who reported favorably, but on account of the expense and the time that Mr. Edison would be taken from his experimental work, upon which the development of the business in new lines depended, we deferred bringing suit, in view of the fact that the defendant company was not seriously competing with us. In 1883, we had an investigation made of all the incandescent electric light plants put out by the defendant company, and the conclusion drawn from the investigation was that defendant company's competition was not serious enough to make it worth while to bring suit. Publicity was given to the fact of our having reached this conclusion by the announcements issued by the Edison Company, or its agents, and through the public press. Reference is made to article in "Paterson Daily Press," Sept. 2, 1882, and to the announcement by Spencer Borden, New England agent for the Edison Company for Isolated Lighting, dated Boston, Nov., 1883. V., 3858-9.

Our company had nothing to do with the patent litigation abroad, but I remember that the French suit was brought against an incandescent lamp, well known to us at the time as the Maxim lamp, manufactured by the United States Electric Lighting Company. V., 3869-70.

Mr. Borden, who was in charge of our New England department, and Mr. Lowrey, are among the parties mentioned by Mr. Borden in his document

INFRINGEMENT—(*Continued*):

dated November, 1883, as urging the officers of the Edison Company to deal summarily with those who were pirating Mr. Edison's inventions. V., 3870.

When our agents complained that the Maxim lamp was injuring them, I had every Maxim lamp installation in the country inspected by representatives of our company. The conclusion reached was that the Maxim lamp was not making headway in a business or serious sense. We took the ground that our energies should be directed to developing our business, rather than be dissipated in litigation, especially when no substantial business progress was being made by anybody else. V., 3871.

We hardly thought a few post-offices or steamboats worth considering, especially when the work was poorly done by those who, by means best known to themselves, succeeded in getting the contracts. A few poorly installed and unsatisfactory isolated plants did not seem to warrant the trouble and expense of litigation. The adoption by the Pennsylvania road of the Maxim lamp on a ferryboat received our careful attention. Mr. Edison's business relations and friendly personal relations with the officers of the road caused him to think they ought to have treated him as fairly, even disregarding all patents, as they would treat anybody else. Whatever official steps were taken emanated from the Edison Company. V., 3871-2.

In my interviews with Mr. Flint I do not remember mentioning this specific patent (*i. e.*, the patent in suit), but have no doubt I stated what our claims were as regards incandescent lamps: that is, I mean that this subject was so frequently talked over in our business, that our principal claims touching the lamp became every-day expressions, and I have no doubt that in my talks with Mr. Flint, as well as on all other occasions, in speaking of our business I mentioned these things. V., 3877.

The two notices of November 9th, 1882, and June 12th, 1882, were, to the best of my recollection and belief, addressed and served by personal notice on the defendant. Our company having adopted the policy of going ahead and developing the business without stopping to expend our time and forces in litigation, attempted to give such notice of our legal rights as would show that there were no laches on our part, in case, at a later date, we found a competing company of sufficient importance to sue. I do not find that the patent in suit is emphasized in these notices. I think we served other notices on the defendant company. In conversations between officers and directors of the two companies, in correspondence and in the newspapers, we emphasized at all times the fact that the Edison patents gave us the monopoly of incandescent lighting, and we always spoke particularly of the filament patent as one of the most important. V., 3878-9.

INFRINGEMENT—(*Continued*):

We did not serve other notices upon the theory that those served were not sufficient, but it was our intention to issue circulars from time to time, as patents were granted, so as to give people legal warning. We considered that the Edison patents gave us a monopoly of the manufacture of a commercially successful lamp; we regarded the Maxim lamp as an infringement, and hold to-day that it is impossible to make a commercial incandescent lamp without infringing some of the Edison patents, and my belief is, without infringing the patent in suit. V., 3880.

In May, 1885, the Edison Electric Light Company brought a suit against the Swan Incandescent Electric Light Company. I ceased to be an executive officer in 1884, but my impression is that the Swan lamp, like the Maxim, had never been a serious competitor, nor one worth suing in the Courts. At the commencement of our business we had to train men, start factories and lay the foundations for this entirely new and difficult industry. Our reasons for not immediately suing infringers were, first, that our time could be better employed; and, second, that no infringer was then worth suing. I never fixed any volume of business to be done by them which should mark the time when we should begin suit. V., 3882.

Our agents did complain of the competition of the agents of the Maxim lamp and of their representations, and it is quite likely that our agents urged us to bring suit. But we satisfied our agents that the cure was not in litigation, but in exposing the falsity of the claims of the selling agents of the Maxim lamps. That was done by the circular referred to. V., 3883.

In the early history of our business there were two opinions about bringing suits on patents. The lawyers, notably Mr. Lowrey and myself, wanted suits brought at the start, but the business men, and especially Mr. Edison, considered no then-infringer worth suing, and that we could not afford to dissipate our energies. Our experience in this suit shows that, if we had begun suits at an earlier period, we should probably not have done anything else. Our business men were stronger than our lawyers, and no suits were brought. All we aimed to do was to preserve our legal rights by adequate notice. V., 3884.

Our earlier circular, containing a list of broken-down Maxim plants, was criticised as not being full and accurate. I therefore sent out a circular to agents, sending at the same time a copy of the earlier paper, and asked them to take especial pains to verify every statement made in the earlier paper, and give actual information about all Maxim plants in their several agencies. This action on my part resulted in the circular of December 10th, 1883. This circular was an honest attempt to tell the strict truth about the Maxim plants, and I have no reason to doubt the accuracy of our agents' reports. V., 3885.

Our object in getting at the facts contained in this circular was to give our agents the means of stating why we did not sue. We wished to give

INFRINGEMENT—(*Continued*):

them facts, namely, that the Maxim plants were not commercially successful, and that the United States Company was not a competitor in a business sense. V., 3886.

LICENSES GRANTED BY EDISON CO.:

While I was connected as an officer with the Edison Company, many licenses were granted to organized companies for introducing the Edison incandescent light in towns and cities. These companies received licenses under the Edison patents, including the patent in suit, each for a limited territory. In August, 1886, the company had in operation fifty-eight central station plants. V. 3859-60.

PATENT IN SUIT:

The patent in suit, known as the "Filament" patent, was always considered by us as our most controlling patent upon incandescent electric lamps. Upon the French and English patents corresponding to this patent suits were brought against the owners of the Maxim patent in France, and the manufacturers of the Swan lamp in England. References to publications show that the Edison Company claimed that all incandescent lamps infringed the Filament patent. V., 3856-7.

As early as 1880 we contemplated bringing suit against defendant company upon the Filament patent, and in 1881 employed counsel and experts to investigate, who reported favorably. But in consideration of the expense and interference with development of business, and the fact that the competition was not serious, we deferred bringing suit. V., 3858-9.

Many licenses were granted to organize companies under the Edison patents, including the patent in suit. V., 3859-60.

The fact that we considered the patent in suit as the most important patent in connection with the lamp, was continually put forward in our dealings with the public and in our interviews with parties engaged in electrical affairs. The "Commercial Advertiser" Exhibit, August 8, 1882, particularly specifies this patent and sets forth its claims. The claims are set forth with care and under my own direction. V., 3863.

I adopt the statements in the "Commercial Advertiser" of August 8th, 1882, substantially as printed with reference to the patent in suit. No. 3 of the newspaper statement is an imperfect statement of the third claim, and No. 2 is an imperfect statement of claim two of the patent. The newspaper statement of the scope of these patents is substantially the same as the statement of their scope in the Twenty-first Bulletin of the Edison Company, page 60. My recollection is that these four statements were intended to be a fair statement of what, in our opinion, our patents covered, and that these claims were carefully prepared, and were used on different occasions. The first two claims seem to me to be the only ones

PATENT IN SUIT—(*Continued*):

which can be properly compared. They both refer to an exhausted glass globe. The first claim is broader than the second. The third claim does not refer to a globe, which is one of the principal features of the first two claims. The fourth claim relates merely to a method of manufacture. The first claim refers to a continuous conductor without regard to material. The third claim refers to a filament of carbon of high resistance. The fourth claim refers to a carbon. V., 3863-3866.

It is not true that Mr. Lowrey doubted the validity of the patent in suit. From first to last, Mr. Lowrey has uniformly stated his opinion that this patent was good, and could be sustained against any infringer. Moreover, Mr. Lowrey, on many occasions, urged upon the officers of the company the importance of litigating this patent. The correction which was made in December, 1883, was probably made at his suggestion, and was done simply as an extra precaution, to avoid any possible danger in regard to the term for which it was issued. V., 3868.

We took advantage of the French suit to get before the public a statement to the effect that our principal patent, and, notably, our filament patent, controlled the incandescent lamp. We always made a feature, and a prominent one, of the filament patent. V., 3869.

EDISON, Thomas A.

ART. HISTORY OF:

In 1878, when I actively took up the subject of electric lighting, no apparatus, so far as I know, had been devised that would in any measure fulfill the conditions necessary for interior illumination. The arc lights introduced in that year in Paris and a year or so later in this country were of several hundred candles, and I did not consider them suitable for interior illumination. My idea was to subdivide the electric light into small units comparable with the ordinary gas jet. The general scientific opinion was that it could not be done, and even after it had been announced as accomplished by me in 1879 the statement was discredited, and many eminent scientific men, both in this country and abroad, pronounced it an impossibility. The English Parliament appointed a committee to examine into the general subject, and they called before them as witnesses nearly all the prominent scientific men of England, all of whom, with the single exception of Mr. Tyndall, pronounced it an impossibility. Mr. Tyndall said he would hardly go that far; he would not say it was impossible, but he would not like to undertake the solution of the problem. Incandescent lamps had been proposed more than a quarter of a century previous to my taking the subject up, but not only had no practicable incandescent lamp been made, but the conditions of a practicable lamp had not been predetermined, nor had any comprehensive system been devised whereby practicable small lamps could be used to supplant gas as a general illuminant. Dynamos and lamps must be constructed mutually suitable, and all parts of the system must be constructed with reference to all other parts. The problem that I undertook to solve was stated generally, the production of the multifarious apparatus, methods and devices, each adapted for use with every other, and all forming a comprehensive system, whereby electricity properly controlled and directed could be distributed over large areas through the streets of a city and supplied to houses, in which it would feed incandescent electric lamps of moderate candle-power, which would be entirely under the control of the householder, the whole to be on the same scale as present system of gas distribution and affording the same character of convenience to the users. The first thing necessary was a comprehensive system of distribution by a network of conductors all connected together, so that in a city area the lights could be fed with electricity from several directions, thus eliminating the disturbances to any particular section. *Second*, to devise an electric lamp about the same in illumination as the gas jet, possessing qualities necessitated by small investment in copper conductors. Each lamp must be independent, must be so economically produced as to complete commercially with gas, must be durable, easily handled by the public, cheap to manufacture,

ART, HISTORY OF—(*Continued*):

and remain incandescent and stable a great length of time. *Third.* A cheap, accurate and reliable meter must be devised. *Fourth.* A system of conductors capable of being placed overhead or underground; capable of being tapped at proper intervals, with protecting pipes for the copper conductors; also manholes, junction boxes, connections and the various paraphernalia of a complete system of underground general distribution. *Fifth.* I had to devise means of producing at all points, and on an extensive area of distribution a practically even pressure analogous to gas, so that all the lamps should give an equal light at all times. *Sixth.* I had also to devise economical dynamo machines for converting steam power into electricity, and means for bringing them into proper relations with the work to be done. *Seventh.* I had to devise means for preventing the current becoming excessive and causing fire or other injury, and switches for turning the current on or off. I set out to find an entirely new industry and art. Nothing of this character had ever been undertaken before, and the accomplishment of this result presents at almost every point problems of the utmost difficulty, the solution of which was not suggested by anything that had gone before in the art, but required a great amount of experiment and labor (McKeesport suit). V., 3128-32.

In 1878 I entered into relations with the Edison Electric Light Company, under an agreement by which I was to perfect the system that I had in contemplation. I immediately increased my working force at Menlo Park; engaged mathematicians, scientists and mechanics, and began experimenting on a large scale. In December, 1879, I gave a public exhibition at Menlo Park, lighting up the grounds and buildings with my carbon filament lamps which I had then brought to what I considered commercial perfection. The company did more or less business in the way of selling isolated plants, but it was not until the fall of 1882 that a complete central station was in operation. It was designed to supply 16,000 lamps, and covered an area of about one square mile; the engines and dynamos for generating the current were located in Pearl street. The first cost of this plant was about $600,000. Since the erection of the first central station plant, a large number have been installed by the Edison Light Company and its agents. Factories had to be built; tools and methods of manufacture invented and devised, and works established for making lamps. I caused the establishment of Bergmann & Co., for the manufacture of lamp sockets, meters, switches, safety catches, and other small parts required in electric light plants. I afterwards established the Edison Machine Works, and the Electric Tube Works. These factories were put up at my own expense, and in them, as superintendents, were placed men who had been connected with me in my laboratory. There was no skilled body of artisans from which the company could draw. All had to be trained by me, and had to have my careful and constant supervision. After the first station had been built the public were to form companies and install my system. There were not then, as now, electrical engineers. The art was then new, and I had to educate

ART, HISTORY OF—(*Continued*):

the men. I spent much time and money in establishing and carrying on training departments, and many of the persons whom I instructed, after acquiring knowledge of my system, left my employ and used the knowledge they had acquired against my interests and those of the company (McKeesport suit). V., 3132-5.

The general appreciation of the problems inherent in the practical part of the art has been greatly acquired by experts since January 9th, 1880 (McKeesport suit). V., 3141.

BURNER:

In an exhibit dated November 1st, 1877, are shown lamps made by me giving light by the incandescence of boron, silicon and other substances included in the electric circuit, such lamps being arranged in series and in multiple arc. Another paper, dated December 3d, 1877, shows that we were trying to subdivide the electric light into a small number of burners, where the circuit was closed by solid conductors. The reason why silicon and boron were tried was because they were not subject to oxidation like carbon, and lasted longer. These experiments with the carbon, silicon and boron were not considered commercially satisfactory, and were laid aside (Interference Record). V., 3020-1.

BURNER OF CARBON:

My next experiment with carbonized paper was the use of the same in a telephone about May or June, 1877. In 1877 tried every conceivable form of carbon in telephones. About August or September, 1877, strips of carbonized paper were placed in vacuo and brought up to incandescence. Many experiments were tried upon the incandescence of boron, silicon and carbon, in air and vacuo, about that time. Some of these experiments were seen by Messrs. Batchelor, Adams, Herz and Field. In the 1877 experiments two rods of brass, sliding in bearings forming the two poles of the battery, had upon their ends small clamps in which different substances could be clamped. Carbonized Bristol board about an eighth of an inch wide and two inches long was placed in these clamps. The carbon, being brought to incandescence, was quickly oxidized and destroyed, as it was in the open air. Carbon coated with powdered glass was also tried, but did not answer. Experiments were tried on silicon and boron, as the books stated that they did not oxidize when incandescent in the open air. Afterwards tried the experiment in vacuo, but, as we could not obtain a good vacuum, the carbon oxidized almost as rapidly as it did in the air (Interference Record). V., 3008.

The carbonized paper strip used in my experiments about September, 1877, was used as an incandescent conductor in an electric lamp, but not under proper conditions (Interference Record). V., 3009.

In October or November, 1878, my assistant, Mr. Batchelor, made fifty or

BURNER OF CARBON—(*Continued*):

more paper carbons of tissue and other kinds of paper, coated them with lamp-black and tar, and then rolled them into the form of a knitting needle, and afterwards carbonized them by heat. These were included in electrical circuits, and brought to incandescence in vacuo. They were also used in a lamp, shown in my Patent 224,329, where the light was given by the incandescence of the carbon at the point of contact between the electrodes. The carbon did not last very well in vacuo, and we found it very difficult to clamp it so as to prevent the large current used from producing an arc at the point of contact; but in the lamp shown in Patent No. 224,329, they gave better results (Interference Record). V., 3009-10.

We burnt the lamps described in Patent 224,329 for several hours, and our best results were obtained with wood carbon, though we also used carbonized paper (Interference Record). V., 3010-11.

In November or December, 1878, we had our vacuum pump put in order to con- duct some experiments on incandescent carbon conductors in vacuo, and we tried a great number of experiments with paper carbons, wood carbons and carbons made with carbonized broom corn. We found our endeavors blocked in the matters of obtaining incandescent conductors of high resistance and small radiating surface, because we could not make them last any length of time in the best vacuum obtainable with our air pump, which was considered a good one. When, in the course of our experi- ments with incandescent platinum, we had, by our Sprengel pump, ob- tained a high vacuum, it occurred to me that a filament of carbon could be made to stand in the sealed glass vessels we were using, exhausted to a high vacuum. In October, 1879, we made lamps of paper carbon and carbons of common sewing thread, placed in a receiver made entirely of glass, with the wires sealed therein by fusion, and the whole exhausted by a Sprengel mercury pump to nearly the one-millionth of an atmos- phere. These filaments of carbon, owing to their small mass, had a smaller radiating surface and higher resistance than we had hoped: we had reached the conditions where, notwithstanding the carbons were small in mass and filamentary, they were stable. The conditions were, high vacuum in a receptacle in which no deterioration or lowering of the vacuum occurred to destroy the carbon. The results of these experi- ments are embodied in Patent No. 223,898 (Interference Record). V., 3012-14.

About October 22d, 1879, I made a lamp with incandescent paper carbon burner in vacuum bulbs, hermetically closed, which had the character- istics of high resistance, small radiating surface, and sufficient stability and economy to allow of competition with gas. During November a great number of these lamps were made and put up at Menlo Park. Var- ious experiments were tried with them; among others, tests of candle- power, economy, resistance and durability at various degrees of incan- descence. In December, 1879, a great many persons visited my labor-

BURNER OF CARBON—(*Continued*):

atory to see the lights in operation. On December 25th, 1879, about three thousand people visited Menlo Park, and thereafter to the present time all my experiments have been public. Have probably made three thousand lamps containing the paper carbon conductor. In the spring of 1880 I lighted up the steamship "Columbia" with seventy-five to a hundred lamps containing paper carbons, which continued to light the ship satisfactorily for several months. Exhibitions of the paper carbon lamps were made afterwards in various places (Interference Record). V., 3015-6.

The paper carbon incandescent lamps made by me in the winter of 1879-80 were put on chandeliers and run until they were destroyed. Each lamp gave about 12 to 16 candles, and I should judge that the average life was 300 hours. Among the number were two lamps, cut in the same mold, of the same paper and the same size as the others, one of which lasted 1,350 hours and the other 940 hours (Interference Record). V., 3016-7.

About September, or October, 1877, I tried a paper carbon brought to incan- descence in vacuo in an electric lamp. The apparatus was originally a Geissler tube. The apparatus was fitted to the air pump, exhausted, and the cock turned, to preserve the vacuum in the globe of this lamp. Could not make the carbons burn more than a few minutes, on account of inability to obtain a high vacuum. The carbons were made of Bristol board, and were from three-sixteenths to one-sixteenth wide and from eight to fifteen thousandths thick (Interference Record). V., 3018.

The burners of carbon in my lamps made in 1879 had an average resistance of 100 ohms hot, though some were as high as 1,000 ohms (Interference Record). V., 3030.

When a current is passed through a burner made of carbonized blotting paper, little arcs occur throughout the carbon, due to the loose contact of one fiber with another. Carbon conductors made from it are unsatis- factory (Interference Record). V., 3031.

The Sawyer-Man patent (317,676) discloses a lamp suitable for use in series, and not in multiple arc. The ordinary gas carbon is suited to the lamp described in the patent, on account of its low resistance. The use of an incandescent conductor of carbonized paper is taking a contrary direction to what is necessary. If carbonized paper were not used, but carbon- ized paper coated or impregnated by plumbago by some means, and car- bonized, as indicated in the application as originally filed, the resistance of the incandescing conductor might be got down quite low and possibly be utilized. But using all carbonized paper alone in a lamp of this char- acter suitable only to a series system, makes the patent very ambiguous (McKeesport suit). V., 3120.

BURNER OF CARBON—(*Continued*):

There would be no difficulty in making a carbon of the size and shape shown in Sawyer-Man patent (317,676), from a hard carbon mixture such as Carré used in making his pencils. It would be better than paper or the ordinary wood charcoal from domestic woods, but not so good as bamboo (McKeesport suit). V., 3121.

A burner of paper under the most favorable conditions could not compete with bamboo. It would not be possible to obtain as many useful lamps from a given lot as from the more perfect material bamboo, and the life of the lamps would not be so great as in those containing bamboo (McKeesport suit). V., 3141.

CANDLE-POWER:

We burned the paper carbon lamp made in October, 1879, for more than half an hour at 30 or 40 candles. At from 12 to 16 candles it lasted over one hundred hours continuously (Interference Record). V., 3061.

If in a vacuum we can obtain eight lamps of sixteen candles each per horse-power, in an atmosphere of nitrogen at atmospheric pressure we should not get more than one lamp, of sixteen candles, per horse-power, and in an atmosphere of hydrogen, no light at all (McKeesport suit). V., 3125.

Our lamps run down somewhat in candle-power after being used a few weeks. There is no explanation for this. The carbon changes its resistance for some unknown reason. IV., 2598, **10390-1.**

CARBON:

I carbonized paper in the summer of 1876. It was to be used for battery carbons, non-conductors of heat, electrical resistances and a great many articles. Pieces of cardboard and Bristol board were cut into strips, placed in gas tubes, and carbonized in a furnace by heating the tubes white hot. The strips were packed in the tube one upon the other, and the interstices filled with charcoal powder. Means were adopted to keep them straight while being carbonized. Experiments were made to carbonize small crucibles made out of Bristol board. These experiments were quite extensive. It was the intention to go into the business of making carbon wire for various purposes, electrical and chemical, for electric lighting and batteries. Mr. Chas. Batchelor and Mr. E. H. Johnson saw many of the experiments. Mr. Adams, one of my assistants, helped me in the experiments. We also carbonized wood made up in various shapes, as well as paper (Interference Record). V., 3006-7.

The paper carbons made by me in 1876 were very fair, after we got the idea of carbonizing them under strain and pressure. We determined the quality of these carbon strips as to electrical resistance by placing them in electrical circuits and working sounders through them. We also placed one of the crucibles in circuit, and boiled water by the heat en-

CARBON—(*Continued*):

gendered by the passage of the current. We compared the resistance of these carbons with that of metal. The resistance, as compared to metal, was very much higher (Interference Record). V., 3007.

Blotting-paper when carbonized is loose, non-coherent and friable. Some kinds of blotting-paper separate in carbonization into two or three layers (Interference Record). V., 3031.

I first began experiments on carbonized paper in the summer of 1876, about June or July, and continued them for about two months. In January or February, 1877, I used carbonized paper in my telephones, and for resistances; used carbon made from paper, because it was a convenient form. We also carbonized wood of various kinds, as well as paper. In our telephone experiments we required very thin carbon, hence paper was the most convenient (Interference Record). V., 3040-2.

I knew from my experiments in 1876 and 1877, in which I employed carbonized paper and other carbonized organic substances for resistances, that carbon in that state of aggregation had high resistance, as compared with hard or coke carbon, and was the proper form to use for incandescent conductors for electric lamps, if they were to be worked in multiple arc (Interference Record). V., 3086-7.

Paper carbon for use as an incandescent lamp conductor should be free from adulterations, compact and well carbonized. It will then have high specific resistance, and, if cut as a filament, the lamp in which it is used will have a high resistance (Interference Record). V., 3091.

All kinds of carbon, except, perhaps, the diamond, are the same, their different appearances being due to their structural arrangement. Thus hard gas retort carbon and paper carbon are the same kind of carbon, their difference consisting in their structural arrangements. Paper carbon, wood carbon, and all carbon derived from vegetable organic matter of cellular formation, when carbonized are very porous, hence the resistance to the passage of the current through a square millimeter section and one inch long, would be very much greater than if the same was made of hard retort carbon. As high resistance is desirable to make a commercial incandescent lamp, paper and other organic carbon has the desirable quality, owing to its cellular structure giving such high resistance. High resistance to the passage of the current allows of commercial subdivision, and this quality organic carbon is possessed of (Interference Record). V., 3092.

In order to make it suitable for use as a burner in an incandescent lamp, carbon must have the following quantities: Uniformity of structure, though it is not essential that it be hard. The texture need not be fine, nor solid, cellular structure being preferred. The cells or interstices may be small or large, provided the total weight of the carbon between the

CARBON—(*Continued*):

electrodes, with a given radiating surface, be far less than if the carbon was perfectly dense. The burner, as a whole, must have a high resistance (Interference Record). V., 3092-3.

I ascertained, in 1876 and 1877, that paper carbon had high resistance, and a proper resistance for use in multiple arc. I was aware when I made the first incandescent lamp that organic carbon was the proper kind to use, since with small mass, it had high resistance (Interference Record). V., 3093.

We use a special kind of bamboo, which is found and cut for us specially in Japan. I have sent to various parts of the world seeking for a kind of bamboo which might prove better, and also for all kinds of other material. I should say that I have received, and carbonized, made into lamps, and tested not less than six thousand different species of vegetable growth (McKeesport suit). V., 3103-4.

Of all these vegetable growths, I find useful for my purposes only about three species of bamboo and one species of a peculiar cane that grows up in the regions of the Amazon, and one or two species of fibers from the agava family. Of the bamboo which we now use, only the extreme outer edge of the cylinder, after the removal of the silicious epidermis, can be used. The thickness of the walls of the cylinder is about three-eighths of an inch. Of this we use twenty thousandths of an inch; but the best portion is the first ten thousandths of an inch from the edge. It is at this point where the fibers are more nearly parallel, and where the cell walls of the fibers are apparently the smallest, and where the pithy matter between the fibers is at its minimum. In forming the filaments from the bamboo, it must be cut as nearly as possible parallel with the fibers, for unless this is done, defects are developed during carbonization, and the life of the lamp would be rather short. It would be impossible to cut a filament from the bamboo at right angles to the length of the fiber, and, even if it could be done, I should not imagine it could be carbonized successfully or used at all. If a conductor of the size shown in Sawyer-Man Patent No. 317,676, were so cut that the parallel fibers were cut at right angles, of course it would be of no earthly use (McKeesport suit). V., 3104-6.

About January or February, 1880, we were carbonizing everything that we could get hold of, trying to get a carbon that would be durable under commercial conditions. I took an ordinary palm leaf fan from the table, took off the outer bamboo rim, and gave it to my assistant to cut into burners and try in the lamps. We were surprised to find that these lamps were several times better than any we had succeeded in making. By microscopic examination and other experiments, we discovered the reason of it, and a short time after I sent a man to Japan to make arrangements for a supply of the bamboo. The reason for bamboo being particularly suitable for our purpose is, that fibers run more nearly

CARBON—(*Continued*):

parallel in this species of wood than in any other (McKeesport suit). V., 3108-9.

It is not because vegetable fibers are fibrous that they are adapted for the manufacture of carbons for electric lamps. That fact is rather a disadvantage. If bamboo grew solid, but with a cellular formation, I should consider it absolute perfection, and I do not doubt that incandescent lamps would have a life of at least six times longer than they have now. What is wanted is a cellular structure, even and homogenous in every direction, without fibers, so that in cutting it into shape, it will have the same mass per unit section everywhere, and will on carbonization give the same amount of carbon, so that the carbon thus produced will have the same stress, like well annealed glass, throughout its whole body. The object of the cellular structure is to produce, as a whole, a filament in which the whole of the carbon is a continuous conductor of electricity, so that the whole of it takes part in performing the work; and by reason of the cellular structure, its total resistance as a conductor will be great. Taking such a theoretically perfect filament of carbon, (composed of carbon cells, with air spaces in each cell), the amount of investment in copper conductors will be in proportion to the amount of carbon in the filament. The carbon in the interior of a filament is a positive disadvantage, because it does not give light, and requires a large investment in copper to carry the current necessary to keep it up to such a degree of incandescence as to permit the exterior of the carbon to emit light (McKeesport suit). V., 3109-10.

Of the six thousand kinds of vegetable growths that I have tried, remarkably few were of any value whatsoever for the production of a perfectly commercial lamp, and one easily and cheaply manufactured. Some of the inferior kinds of materials could be used, but the percentage of bad lamps would be so enormous that the cost would be prohibitory (McKeesport suit). V., 3110.

All vegetable fibrous growth is not suitable for manufacture of conductors for incandescent lamps, because in some the cells are so large that they are utterly useless. It seems from experiment that the smaller the cells, the greater will be the life of the conductor. Palm, though belonging to the same family as bamboo, has cells much larger than bamboo, and experiments have shown that the filaments cut from apparently perfect palm fibers did not give one-fifth the life of corresponding bamboo fibers (McKeesport suit). V., 3110-11.

We discontinued the use of carbonized paper, on account of its various defects. It did not give sufficient life; and, if it was attempted to make filaments of high economy, the life was very short. Another difficulty was that paper is so uneven in its texture, and it was difficult to cut the blanks even. Then it was exceedingly difficult to carbonize. In fact, at the time we used paper we found great difficulty in getting a great

CARBON—(*Continued*):

number of lamps free from spots, so that they could be used; but when we got bamboo, our trouble practically disappeared, as all these difficulties, or nearly all, were absent when bamboo was used (McKeesport suit). V., 3113-4.

In the Sawyer-Man specification (317,676) I do not find anything to elucidate the meaning of the sentence about carbonized paper covered with plumbago. It does not state how it is to be used, but I infer that the paper was carbonized and then rubbed over with powdered plumbago. It would require great stretch of the imagination to conceive a practical filament being made in that way (McKeesport suit). V., 3115.

By the term "wood carbon or charcoal," contained in the original specification of Sawyer-Man (Patent 317,676), the art at the date of the application would have understood charcoal made from ordinary wood (McKeesport suit). V., 3115.

The Sawyer-Man patent (317,676) does not give sufficiently definite directions as to choice of the fibrous or textile carbon, its method of preparation and selection of material, to enable a person skilled in the art at the date of the patent to make a practical fibrous or textile carbon for incandescent lamps. The patent does not show anything not already indicated in other patents years before (McKeesport suit). V., 3117.

Not all kinds of paper are suitable for making incandescent conductors, and the papers of different manufacturers vary greatly in their qualities. Blotting paper, roofing paper, and glazed paper would be utterly useless for the purpose. There are not sufficient directions in the Sawyer-Man patent (317,676) to enable a proper paper to be selected without experiment. The original specification of the Sawyer-Man patent does not indicate in any way whether the material is to be cut and shaped before carbonization. The patent as issued contains a somewhat general description, but gives no description as to how it is to be cut, disclosing nothing as to whether it is to be cut lengthwise, or across the fibers. Some kinds of paper would be utterly useless (McKeesport suit). V., 3118-9.

The statement in the original Sawyer-Man application (Patent No. 317,676) that the inventors have tried carbonized paper covered with plumbago, is no indication to those skilled in the art that the wood carbon is to be formed out of wood previous to carbonization (McKeesport suit). V., 3120.

CARBONIZATION:

I carbonized paper in the summer of 1876. It was to be used for battery carbons, non-conductors of heat, electrical resistances and a great many articles. Pieces of cardboard and Bristol board were cut into strips,

CARBONIZATION—(*Continued*):

placed in gas tubes, and carbonized in a furnace by heating the tubes white hot. The strips were packed in the tube one upon the other, and the interstices filled with charcoal powder. Means were adopted to keep them straight while being carbonized. Experiments were made to carbonize small crucibles made out of Bristol board. These experiments were quite extensive. It was the intention to go into the business of making carbon wire for various purposes, electrical and chemical, for electric lighting and batteries. Mr. Chas. Batchelor and Mr. E. H. Johnson saw many of the experiments. Mr. Adams, one of my assistants, helped me in the experiments. We also carbonized wood made up in various shapes, as well as paper (Interference Record). V., 3006-7.

I have tried experiments on the carbonization of paper, and I do not see how it is possible to produce a carbon which could be used in a lamp by simple carbonization of the paper by the heat produced by the passage of the electric current, in an atmosphere of nitrogen, hydrogen, or air (Interference Record). V., 3032-3.

It is important in carbonizing conductors for incandescent lamps that they should be restrained from free movement during the act of the decomposition of the cellular or other compounds into carbon; otherwise, especially if they are filaments, they are greatly distorted, and if distorted, there is an unequal stress among the particles of carbon, which causes unequal resistance, and a liability to rupture by the expansions produced by the high temperature used with the carbon. By carbonizing the filaments under strain and pressure, the conductor will be as nearly homogeneous as it can be made. The life of the filament when in the lamp depends very largely on such even carbonization. Several patents have been issued to me for means of securing this even carbonization (McKeesport). V., 3101-2.

Distortion and unequal carbonization may be prevented to a certain extent by packing the slips in powdered carbon, without any additional devices. But there is very little strain or stress in this condition of carbonization, and you do not get so homogeneous a carbonization, although distortion is, in a great measure, prevented. Such incandescing conductors will not last so long as those carbonized under proper conditions of strain and pressure, although such conductors are sufficient when they are to be subjected subsequently to what is known as the "flashing" process. This puts a coating of hard carbon on their exterior, which deposited carbon really directs the current from the original carbon, and relieves the carbonized carbon from doing as much work as it would if used without the deposited carbon (McKeesport suit). V., 3102.

"By long experience and the most careful and exhaustive investigations, I have been able to bring the process of preliminary carbonization in furnaces to such a state of perfection that a sufficiently large percentage of good carbons is obtained from the furnaces to enable me to make lamps

CARBONIZATION—(*Continued*):

having the pure vegetable carbons, which need no mineral deposit to make them useful, and only require the process of final carbonization to perfect them for use. In order to make carbons of this character, however, the process of preliminary carbonization has to be conducted with great skill. * * * We have lost many large lots of carbons in carbonization, and at times we have entirely lost the art of carbonization, due to some failure in matters of detail which we could not discover. * * *" In France and Germany the lamp factories were conducted by skilled men, who had been instructed by me; but by reason of failure in carbonization, due to unknown difference in conditions, the lamps made there were commercial failures for some time, and the hydro-carbon treatment had to be resorted to in order to obtain commercial lamps (Canadian affidavit of 1888). IV., 2622-4, **10488-96.**

In my Canadian affidavit, in stating that "at times we have entirely lost the art of carbonization," I did not mean that we could not carbonize at all, but that we could not carbonize as well as we had been doing, which resulted in loss of business by competition, which was fierce. When I lost the art I did not resort to the use of the hydro-carbon, as was done by the makers of Edison lamps abroad. IV., 2552-3, **10206-9.**

During carbonization, tar-putty filaments distort very little; it is those things like cellulose that are very liable to distortion. Paper distorts considerably and bamboo not quite so much. We do not put strain or pressure on bamboo when we carbonize it. When we used paper we used to lay a weight on the top of it to prevent it from curling up. My impression is that thread in carbonization stays where it is put and shows no tendency to distort. As early as 1876 I knew that paper should be put under strain and pressure to prevent distortion, and at that time I used a weight on top of the paper. Carbonization under strain and pressure tends to make filaments look better, but it is not absolutely essential when they are confined in a space which will prevent them from too great distortion. IV., 2562-4, **10247-55.**

Batchelor's Note-book No. 52 shows that at that time we had considerable trouble in carbonizing tar-putty filaments. We finally overcame the trouble by winding the filament in a spiral form between a copper spiral, as described in the patent in suit. IV., 2595, **10377.**

CLAMPING:

Very great difficulty was encountered in clamping the paper carbons used in Patent No. 234,329, so as to prevent the large current used from producing an arc at the point of contact between the electrodes (Interference Record). V., 3009-10.

The ends of our paper carbon burners were thickened or broadened. This was necessary in order to get a better clamping to the leading wires and to prevent heating at that point. Think that about October 22nd or 23rd, 1879,

CLAMPING—(*Continued*):

we made a paper carbon with thickened ends for the purpose of making a contact with the leading wires. The lamps made about November 1, 1879, were made of paper, and the ends were broader than the loop. These broad ends were for the purpose of diminishing the temperature so that better contact could be made with the platinum clamps which were used. In November, 1879, we made paper carbons without thickened ends, but the ends were electroplated with copper and then put into the clamps. They worked very well. It is important that the connection between the leading wires and the carbon should be made good; to this end it is necessary to have a larger mass of matter at that point in order that the whole is not brought up to a temperature which would make bad contact. IV., 2565-7, **10258-66.**

CLAMPS:

Used clamps as a method of connecting the burner to the leading wires in December, possibly in November, of 1879. IV., 2564, **10256.**

COMMERCIAL SUCCESS:

Have probaby made three thousand lamps containing the paper carbon conductor. In the spring of 1880 I lighted up the steamship "Columbia" with seventy-five to a hundred lamps containing paper carbons, which continued to light the ship satisfactorily for several months. Exhibitions of the paper carbon lamps were made afterwards in various places (Interference Record). V., 3015-6.

Do not know whether I was the first to recognize the advantage of placing incandescent lamps in multiple arc. "I believe that I was the first man to make multiple arc lighting with incandescent lamps practicable and commercial." IV., 2604, **10415.**

CONDUCTORS:

With a filament of carbon of high resistance and small radiating surface, smaller conductors can be used, since owing to the high resistance of the lamps, weak currents are only necessary, and sufficient energy to produce the result is forced through wire and lamp by increasing the electromotive force (Interference Record). V., 3022.

"The copper question is very serious for multiple arc lighting, even in short distances, but is not a question at all in series lighting." IV., 2589, **10356.**

CROSS-SECTION:

The smallest filaments which I have ever made which would give good commercial results were two and one-half thousandths of an inch in diameter. Think it is practicable to make them as small as one-thousandth of an inch in diameter, and I am trying to do so now. This would be a desirable result to accomplish, as with lamps in multiple arc it would save copper in the conductors. IV., 2599, **10394-6.**

DISCOVERY:

As to the kind of carbon which I first put into a highly exhausted all-glass globe, "It was a thread carbon, and, if I remember right, it was on the 21st of October, 1879, that broad sunlight was thrown on this business of incandescent lighting. I mean to say that I discovered the fact that carbon would stand high temperatures, even when very attenuated, in a high vacuum, without the phenomena of disintegration, which took plece in all the previous attempts that I know of, when trying to use carben to make an incandescent lamp." It was with the lamp having the carbon thread in a highly exhausted all-glass globe "that I discovered this all-important fact that something which was expected to take place did not take place, and this discovery permitted the use of fine filaments and carbon of high specific resistance, and made incandescent lighting, as we know it, commercially practicable." In this experiment "I expected that there would be a disintegration of the carbon to a certain extent. How much, was the object of the experiment." This lamp did not show any disintegration: "none that we noticed, up to the time that we broke the lamp by bringing it up to an enormous temperature, where we expected it to break." There is a disintegration which goes on in all modern lamps, but "That disintegration in good lamps was not noticed for some time, because it takes, in a well made lamp, several hundred hours to show disintegration by a slight blackening of the globe: but as that takes two or three months to find that out we could not have known it at the time. However, the disintegration has never been of any moment." "The discovery I made was that a fine filament of carbon, under the conditions I had, did not disintegrate to any extent. That was the discovery as set forth in my patent, but the patent has also in addition some invention as well as discovery: in other words, it required invention to carry out the discovery which I made." Before trying the experiment of October 21, 1879, "I expected that it (the carbon thread) would wear away gradually, but hoped that the wearing away would not be so great under the conditions I had as to prevent its use at the temperature which I proposed to run it at." "In trying an experiment I always expect something of advantage. I thought in this case that the wearing away would not be so great as to prevent the use of the lamp for commercial lighting, but I did not expect that it would not wear away at all." "I did not expect that it (the lamp tested October 21, 1879) would run at the candle-power that I put it at without showing signs of disintegration." This lamp "worked enormously better (than I expected). There was a gigantic difference between a little fine filament wearing away and not wearing away, because wearing away with such a fine filament in a very minute degree would prevent long life. The fact that it did not wear away was a great surprise, and I have called this a discovery as stated in my patent." "I expected that it (the carbon thread) would wear away, and the discovery I made was that it did not wear away under the conditions I had put in the lamp." "We could (with this lamp) discover no wearing away. We only discovered that they did almost inappreciably wear away after we had made a great

DISCOVERY—(*Continued*):

number of lamps and set them up and waited a long time to see." IV., 2557-9, **10225-36.**

I had had a good deal of experience with carbon as an illuminant before making my all-glass globe, and expected in such a globe with a high vacuum to maintain carbon as a burner, otherwise I would not have tried the experiment. When I did try the experiment the results were far more favorable than I expected, as set forth in my patent. I have always believed that I was the first one to discover the fact that carbon when subjected to a high temperature in a high vacuum, formed in an all-glass globe, will remain stable. I did not, as the result of my early experiments, assume that the deterioration of carbon was due to oxygen attacking it. As to my expectation that the carbon would remain stable in a highly exhausted all-glass globe before trying the experiment, "I thought it would remain stable as far as oxidation was concerned, but I did not think that disintegration would be prevented, because I had read something about incandescent lamps, and it seemed to me that they all universally stated that there is a deterioration; that a great many persons who have experimented with incandescent lamps stated that there is a blackening of the globe. Now, this blackening could not be due to oxygen, because there would be no blackening. The oxygen would form carbon monoxide. I saw, independent of the oxygen, there must be the matter of disintegration that I was afraid of, but I thought, perhaps, having got rid of all oxygen, this disintegration would not be so large a factor as to prevent the use of a lamp for commercial purposes, and the discovery I made was that this did not take place under the conditions of a high stable vacuum." IV., 2580-1, **10318-22.**

When I had made my all-glass lamp with platinum burner and had found that it would hold its vacuum, "I believed that by substituting a filament of carbon for that of platinum it would be stable. I did not have any doubt but what I could make a filament of carbon sufficiently homogeneous for the purpose. The platinum burner which I used, however, did disintegrate to the extent of tinting the globe with a vapor of platinum, and I supposed that this effect would take place even when I used the filament of carbon under the conditions, but I hoped it would not be to such an extent as to render it uncommercial, and I was surprised to find that it did not blacken at all; and that is the discovery that I set forth in the patent, and I have emphasized the word 'stable' and used instead the words 'absolutely stable.' If a person's dining room is lighted by incandescent lamps, it will be about two years and a half before any blackening of the globes is noticed. I did not know that this would occur when I applied for my patent and could not wait six or eight months to find it out. IV., 2584, **10333-6.**

Mr. Batchelor's note-book, No. 52, contains on pages 111 and 115 a lamp called

DISCOVERY—(*Continued*):

No. 9. This record, if my memory serves me right, is the carbon thread lamp which was tested on October 21, 1879. The record is as follows:

"(Page 111.) No. 9, ordinary thread, Coat's 6 cord, No. 24 S. Came up to ½ candle, and was put on 18 cells battery permanently at 1:30 A. M. (Page 115.) No. 9, On from 1:30 A. M. to 3 P. M. 13½ hours, and was then raised to three gas jets for one hour, then cracked glass and busted."

I do not rely on this particular record for my statement that the experiment with the carbon thread lamp was made on October 21, 1879. I rely "upon my memory absolutely, because it was a great day for me." I used to keep some records myself, and my assistants kept some. "I do not think I kept many just about that time." As to the likelihood that I would have made a note in my personal record of an experiment so important as this, "it would be a most unlikely time for me to make records. Such details were trivial in view of what I had got hold of." IV., 2592-4, **10368-76.**

DISTRIBUTION OF ELECTRICITY:

The problem that I undertook to solve was, stated generally, the production of the multifarious apparatus, methods and devices, each adapted for use with every other, and all forming a comprehensive system whereby electricity properly controlled and directed could be distributed over large areas through the streets of a city, and supplied to houses in which it would feed incandescent lamps of moderate candle-power, which would be entirely under the control of the householder, the whole to be on the same scale as the present system of gas distribution, and affording the same character of convenience to the users. The essentials of a comprehensive system of electric illumination, similar to the general plan of illumination by gas, were a net-work of conductors all connected together, so that in a city area the lights could be fed with electricity from several directions, thus eliminating the disturbances to any particular section. The system of conductors had to be capable of being placed underground or overhead, of being tapped at necessary intervals, and when the conductors were to be placed underground, a system of protective pipes had to be devised; also manholes, junction boxes, connections, and the various paraphernalia of a complete system for underground general distribution (McKeesport suit). V., 3130-1.

DURABILITY:

The paper carbon incandescent lamps, made in the winter of 1879-80, lasted on an average about three hundred hours. One lasted 1,350 hours and another 940 hours (Interference Record). V., 3017.

Mr. Sawyer, in 1879, in a communication to the New York papers, said that a paper carbon lamp, even if in a perfect vacuum, would not last twenty minutes (Interference Record). V., 3036.

DURABILITY—(*Continued*):

Incandescing conductors carbonized by simply packing the slips in powdered plumbago, without being subjected to strain and pressure during carbonization, will not have the same life as conductors carbonized under proper conditions as to strain and pressure, although such conductors are sufficient when they are to be subsequently subjected to the hydro-carbon treatment (McKeesport suit). V., 3102.

It seems, from experiment, that the smaller the cells in vegetable fibers, the greater will be the life of the conductor. The cells of palm are much larger than those of the bamboo, and our tests have shown that filaments cut from apparently perfect palm fibers did not give one-fifth the life of corresponding bamboo fibers (McKeesport suit). V., 3110-11.

A lamp made according to the patent of Sawyer-Man (No. 317,676), if run at the same degree of incandescence as the incandescent lamp now sold throughout the country (*i. e.*, 240 candles per electrical horse-power), would not last for a period of 24 hours (McKeesport suit). V., 3139.

Lamps made of paper, under the most favorable conditions, would not last so long as those made of bamboo (McKeesport suit). V., 3141.

The carbon burner tried in my exepriments in 1878, under the bell jar of an air pump, lasted about a minute. IV., 2585, **10339.**

I find from the records that the life of our lamps made in December, 1879, and January, 1880, averaged 400 hours. IV., 2597, **10385.**

The life of a carbon filament of given size and length depend upon the mode of manufacture, the material, and a great number of things. IV., 2597, **10387.**

DYNAMOS:

In 1878, when I actively took up the subject of electric lighting, I had to devise economical dynamo machines for the conversion of steam power into electricity, means for connecting, disconnecting, working and regulating the same; means for equalizing their loads; means for regulating the number of machines to be used to the demands on the station for electricity from the users of the light (McKeesport suit). V., 3131.

ECONOMY:

Filamentary carbon burners of high resistance and small radiating surface are economical, because smaller conducting wires can be used for conveying the current. If lamps of low resistance were placed in multiple arc in a single circuit, the aggregate resistance of all the lamps would be low, and conductors of correspondingly large dimensions would have to be used, otherwise a great loss of current in the form of heat would take

ECONOMY—(*Continued*):

place on the conductor. Again, economy is attained from the fact that these filaments of carbon, being small in mass, conduct very little heat from the incandescent burner to the clamps and supports. High vacua render the carbon horseshoe stable, and at the same time result in great economy in the use of electricity, as practically all the energy is lost by radiation, and none by conduction (Interference Record). V., 3023.

EFFICIENCY:

The efficiency of incandescent lamps is being improved by improvements in the details of manufacture (McKeesport Suit). V., 3142.

ELASTICITY AND FLEXIBILITY:

The paper horseshoe, being of small radiating surface and small in mass, is very flexible and tough. Hence the lamps may be handled practically with impunity, so far as breaking the carbon horseshoe is concerned. The horseshoe shape permits the carbon to expand and contract freely without injury (Interference Record). V., 3026.

EVAPORATION:

At the date of application for the patent in suit, after having found out that these fine filaments did not give the phenomena of disintegration under the conditions of high vacuum, we started in to try a great many different kinds of materials to see which was the most commercial. IV., 2556, **10223.**

"I have spent over a hundred thousand dollars in trying to find out" (what causes the blackening of the globe of a modern incandescent lamp), "and I don't know." IV., 2581, **10323.**

The lamps made by me in 1880 generally showed a slight tinting of the globe after burning three or four weeks. IV., 2585, **10337.**

The speedy destruction of the carbons of my earliest experiments, in 1877 and 1878, was caused by oxidation. IV., 2597-8, **10388-9.**

Also see Discovery.

FILAMENT OF CARBON:

The well-known carbon horseshoe lamps made in October and December, 1879, were illustrated in the "New York Herald," of December 21st, 1879. These were made of carbonized paper, and were durable enough to compete with gas. They had high resistance, small radiating surface and were economical, because owing to the resistance of the lamps weak currents only were necessary. With small radiating surface, less energy is required to produce a candle-power than on a larger surface. Economy is attained, because these filaments of carbon, being small in mass, conduct only little heat to the clamps and supports. High vacua render

FILAMENT OF CARBON—(*Continued*):

the carbon horseshoe practically stable, and at the same time economical in the use of electricity, as practically all the energy is lost by radiation, and none by conduction. My experiments have shown that if a carbon horseshoe is placed in an atmosphere of nitrogen at the atmospheric pressure, which is the method adopted by Mr. Sawyer in his lamp experiments, it requires nearly twice as much electricity to bring the horseshoe up to the same candle-power as it does when the horseshoe is in a high vacuum. Heat is lost by conduction through the gas to the enclosing globe, from which it radiates invisibly. Hence my lamp is, I believe, the first one ever produced that was commercially available for competition with lighting by gas, and of great utility (Interference Record). V., 3022-3.

The slightest leakage going on continuously would render impracticable the use of the excessively fine filament necessary for the commercial subdivision of the electric light. With separable lamp chambers, as shown in the patent of Sawyer-Man, lighting by incandescence with filaments of carbon could not be a commercial success (McKeesport Suit). V., 3099.

To secure even carbonization, upon which the life of the filaments, when in the lamp, depends, they should be carbonized under strain and pressure (McKeesport Suit). V., 3101.

About the last of January, or the first of February, 1880, we found that lamps which we made of bamboo splints gave us abnormally greater life at high incandescence than any of the incandescing conductors made from other materials; we use bamboo at the present time for our carbon filaments (McKeesport Suit). V., 3102-3.

In cutting or forming the filament from bamboo or other vegetable fiber, the filament must be cut parallel to the fibers. If the bamboo were cut at right angles to the fibers, the filament, even if it could be formed and carbonized, would be of no earthly use (McKeesport Suit). V., 3104-6.

Filaments cannot be successfully made from wood, and I know of no wood of exogenous growth from which a practicable filament could be made (McKeesport Suit). V., 3106-8.

If bamboo grew solid without fibers, but had a cellular formation, I should consider it absolute perfection, and I have not the slightest doubt but what incandescent lamps would have a life at least six times longer than they have now. Taking such a theoretically perfect filament of carbon (composed of carbon cells, with air spaces in each cell), the amount of investment in copper conductors will be in proportion to the amount of carbon in the filament. The carbon in the interior of a filament is a posi-

FILAMENT OF CARBON—(*Continued*):

tive disadvantage, because it does not give light, and requires a large investment in copper to carry the current necessary to keep it up to such a degree of incandescence as to permit the exterior of the carbon to emit light (McKeesport suit). V., 3109-10.

It seems from experiment, that the smaller the cells of the vegetable fibers, the greater will be the life of the conductor. For instance, filaments cut from apparently perfect palm fibres did not give one-fifth the life of corresponding bamboo fibers (McKeesport suit). V., 3110-11.

Filaments for incandescent lamps are made by different manufacturers of various substances, natural and artificial. Sawyer & Man use bamboo, Siemens Brothers use the fiber of the agave, and I have made filaments from chemical combinations, compounds and mixtures, by squirting, by flowing in sheets, by cutting therefrom, and in many other ways (McKeesport suit). V., 3112.

We had only made a few hundred paper carbon filaments when we discovered the efficiency of bamboo, and made no paper carbons after that discovery, unless it was a few for experimental purposes. Within a month of January 30th, 1880, we adopted bamboo (McKeesport suit). V., 3113.

It would be hard to conceive of a practical filament being made by impregnating paper with powdered plumbago, and then carbonizing it by the passage of an electric current (McKeesport suit). V., 3115.

I had known for a long time, and knew in 1877, that carbon had the requisite resistance to afford a very simple conductor to be used in multiple arc; but I also knew in 1877 that it would have to be made hair-like; and as my results showed that carbons which were far from hair-like, but many times larger in bulk, were destroyed from inability to get a sufficient vacuum to maintain the same, I knew that it would be useless to try a filament which would have the qualities I desired under such adverse conditions. But the moment that I had apparatus and means and methods whereby I made a chamber wholly of glass, and with the McLeod gauge on the Sprengel pump had determined that it held a vacuum continuously, I knew that I could make the hair-like filament permanent, provided the filament itself could be make sufficiently homogeneous (McKeesport suit). V., 3124.

The carbon filament in the Sawyer-Man lamps is made of bamboo, as I ascertained by microscopical examination. The only difference in the carbon is that it was "flashed" by the deposition of the carbon on the surface of the original filament (McKeesport suit). V., 3128.

The filaments of my lamps are a pure vegetable carbon, made by the carbonization of bamboo and without the addition of any mineral carbon. I

FILAMENT OF CARBON—(*Continued*):

consider the success and reputation of my lamp to be largely due to the use of such carbon (Canadian affidavit of 1888). IV., 2622, **10486.**

At the date of application for the patent in suit, after having found out that these fine filaments did not give the phenomena of disintegration under the conditions of high vacuum, we started in to try a great many different kinds of material, to see which was the most commercial. IV., 2556, **10223.**

As to the kind of carbon which I first put into a highly exhausted all-glass globe, "It was a thread carbon, and if I remember right, it was on the 21st of October, 1879, that broad sunlight was thrown on this business of incandescent lighting." IV., 2557, **10226.**

Of the filaments tried prior to application for patent in suit, those made from paper gave the best results. IV., 2560, **10238.**

I knew in 1877 that a carbon burner would have to be "hair-like." How I came to that conclusion I cannot say. I suppose that at that time I must have known that the higher I got the resistance the nearer I would get to the solution of the problem I was after. I had not made any "hair-like" carbon burners in 1877. The conditions were that the burners should be stable, and that was the reason why I started my first experiments in electric lighting by series. IV., 2582, **10325-8.**

In all my experiments, after I had an all-glass chamber and had determined with the Sprengel pump and McLeod gauge that it maintained a vacuum, "I reasoned that, if I could produce a sufficiently high vacuum, I might be able to use a fine filament—not only a large filament, but a fine filament—and that it would be stable outside of unknown phenomena which occurred of the gradual disintegration of the carbon; that I did not know how long it would take to destroy the lamp, but supposed it might be diminished to such an extent that it would still be a commercial lamp." IV., 2583, **10331-2.**

The smallest filaments which I have ever made which would give good commercial results were two and one-half-thousandths of an inch in diameter. Think it is practicable to make them as small as one-thousandth of an inch in diameter, and I am trying to do so now. This would be a desirable result to accomplish as, with lamps in multiple arc, it would save copper in the conductors. IV., 2599, **10394-6.**

As to the difficulty experienced in making carbon filaments homogeneous, "I have made a great number of carbon filaments which I could not imagine were not perfectly homogeneous, and yet they would run for a great number of hours and then suddenly, without any warning, break. This might imply a want of homogeneity, and in that sense, if there is want of homogeneity, then we have had great difficulty." As to my consideration

FILAMENT OF CARBON—(*Continued*):

of this matter in, my answer to question 475, my deposition in the McKeesport suit: "What I meant by homogeneous in that answer was not theoretically homogeneous, but sufficiently homogeneous—sufficiently near alike in all its parts to do the business." IV., 2602-3, **10408-9.**

Also see Discovery.

FILAMENT OF TAR-PUTTY:

In coiling a thread between a helix of copper wire, as mentioned in the patent in suit, we made use of a mandril, as that would be a necessary consequence of coiling anything in a spiral. The tar-putty filament was then allowed to dry, after which it did not require the support of a mandril. The latter was removed before the carbonization. Working in accordance with the instructions contained in the patent in suit, I would use a mandril and would withdraw it before carbonization. These two steps are self-evident. The patent tells me to wind a spiral—the human mind can conceive of no other way to wind it except on a mandril. IV., 2553-4, **10,210-6.**

If the filament were properly wound between the coils of a copper wire helix, the two would not fall apart when the mandril is withdrawn, but would maintain their positions. IV., 2555, **10219-20.**

At the date of application for the patent in suit, I had not made many tar-putty burners. IV., 2556, **10222.**

"The patent (in suit) necessarily would more fully set out descriptively the tar-putty lamps" (than the thread lamps), "as there was more manipulation in this character of lamp." IV., 2561, **10242.**

"The patent, of course, has to describe how such filaments are made, because they were an artificial product. Such a description would not apply to paper because paper we already find in the art, and it would be unnecessary to describe how to make paper. There was no difficulty in producing tar-putty filaments. I would be very happy to produce them before the Judge in court." IV., 2561, **10244.**

The spiral tar-putty filament, produced as described in my caveat of Dec. 22, 1879, is a special case of a peculiar spiral made in a peculiar way, and manipulated in a peculiar manner. The patent in suit does not have this spiral made in a peculiar way, but it simply says a spiral. IV., 2562, **10245.**

Batchelor's note book, No. 52, shows that at that time we had considerable trouble in carbonizing tar-putty filaments. We finally overcame the trouble by winding the filaments in a spiral form between a copper spiral as described in the patent in suit. IV., 2595, **10377.**

GASES:

My experiments have shown that if the carbon horseshoe is placed in an atmosphere of nitrogen at the atmospheric pressure, as in the Sawyer lamps, it requires nearly twice as much electricity to bring the horseshoe up to the same candle-power as it does when the horseshoe is in a high vacuum (Interference Record). V., 3023.

A great many inventors, including Sawyer & Man, placed their carbons in a nitrogen atmosphere, on the theory that nitrogen is inert towards carbon. But it is well known that carbon at a high incandescence unites with nitrogen to form cyanogen and the cyanides due to ash of the carbon. If the inert gas is at atmospheric pressure when cold, it does not remain so when heated, and there is a tendency to force the gas out of the imperfectly sealed chamber of Sawyer & Man. Upon the gas within the imperfectly sealed chamber becoming cooled, the air would force its way in to take the place of the gas forced out when heated. For this reason the lamp would be impracticable (Interference Record). V., 3037-8.

In December, 1879, or January, 1880, we used in the lamp chamber of the paper carbon lamp, hydro-carbon gas, hydrogen gas, nitrogen gas, hydrochloric acid gas and chlorine gas. These gases were used experimentally to determine theoretical points. In December, 1878, and the early part of 1879, I used gases, especially hydrogen, in an incandescent lamp, but in this case a platinum burner was used (Interference Record). V., 3075-6.

No gas that could be used is inert, as all gases have an effect on carbon (Interference Record). V., 3078.

No incandescent lamps are now sold in which the atmosphere is either hydrogen or nitrogen. The experts now know that with an electric current of one horse-power, giving eight lamps of sixteen candles each, when the filament was in a vacuum, the same lamps would not give more than one lamp per horse-power, or sixteen candles, when nitrogen was in the globe at atmospheric pressure; and would give no light at all, if hydrogen were in the globe at atmospheric pressure. It is a most absurd thing to use nitrogen or hydrogen (McKeesport suit). V., 3124-5.

HEATING DURING EXHAUSTION:

In the final process of carbonization which is conducted in the lamp bulb by passing a current through the burner, a heat is obtained which is at least twice as high as that to which the filaments are subjected in the furnace, or when at their normal candle-power. This final carbonization reduces the filaments to pure carbon. The furnace carbonization is a preliminary step which makes the filament a conductor, thereby making it possible to subject it to final carbonization by the intense heat generated by a current passed through it. Since November, 1881, lamps would not have been commercial without subjecting them to this process. They

HEATING DURING EXHAUSTION—(*Continued*):

would change in candle-power and the high vacuum necessary for long life and high economy would be soon destroyed. This final carbonization changes the character of the carbon and materially reduces its resistance and makes the filament practically unalterable under the conditions of use, giving a high economy and long life (Canadian Affidavit of 1888). IV., 2620-1, **10480-4.**

Have used the process at different times since some time in 1879, and always in the regular manufacture of lamps. The lamps used on the steamer Columbia were subjected to this process. At that time, regarded it as a necessary step to obtain a vacuum, because the ordinary heat of carbonization is not sufficient to entirely decompose the carbonaceous compounds from which the carbon burner was made. Do not mean to say in using the words "necessary step," that a commercial lamp could not be made without this process. Think conditions could be found whereby it would not be absolutely necessary, although it would be difficult, as a lamp which was commercial in 1880 would not be perfectly commercial in 1881, and so on. The carbons of the very first lamps made in 1879 were electrically heated before the sealing up of the globe. Remember trying some lamps in 1882, in which the burners had not been electrically heated, and think that they had about half the life of the regular lamps. IV., 2551-2, **10201-6.**

There is a change in the resistance of filaments, after they have been carbonized in the furnace, when the current is passed through them. IV., 2614. **10454.**

HYDRO-CARBON TREATMENT:

In the lamps made of paper horse shoes, which were publicly exhibited, the carbons were not treated. A few of the lamps made in December, 1879, were treated as an experiment. A few of the carbons made in 1878 were soaked after carbonization in tar, and recarbonized (Interference Record). V., 3031.

I do not see that the treating of paper carbon by a hydro-carbon gas, to deposit hard carbon, improves the paper carbon. If the paper carbon was originally bad, it will always remain so. The use of a hydro-carbon for depositing hard carbon by electrical incandescence is only a method for rendering a useless carbon available in an electric lamp. It is, in fact, an evidence of the imperfection of the carbon paper (Interference Record). V., 3033-4.

I have brought up to incandescence a carbon within a lamp containing a hydro-carbon; I have done it in a great number of lamps, a hundred or more; I have tested the economy, the conductivity and other properties of the carbon, and have examined the same many times under a powerful microscope (Interference Record). V., 3079.

HYDRO-CARBON TREATMENT—(*Continued*):

I have tried experiments of heating to incandescence a carbon conductor within a hydro-carbon fluid. It was some time between March and September, 1880 and should say twenty or thirty were thus treated. The treatment reduced the resistance and deposited a crust of hard carbon over its surface which, under the microscope, showed a multitude of projecting points, which were found to be hollow when broken. Both paper and bamboo were thus treated. They were then put in the sealed chamber of an electric lamp and raised to incandescence, with the result that it was of lower resistance and seemed more susceptible to destruction by electrical carrying than the untreated carbon. It was raised (*in a very high vacuum*) to as high as 100 candles, and lasted about two hours (Interference Record). V., 3082.

Hydro-carbon treatment, also called "flashing" process, deposits on the incandescing conductor a coating of hard carbon, which really diverts the current from the original carbon, and relieves the carbonized carbon from doing as much work as it would if used without the deposited carbon (McKeesport suit). V., 3102.

INFRINGEMENT:

I have examined the lamps sold by the Consolidated Company, which lamps were known as Sawyer-Man lamps. They were almost precisely the same as our own lamps. The carbon filament was made of bamboo, which fact I ascertained from a microscopic examination. The only difference in the carbon was that it was "flashed" by the deposition of carbon on the surface of the original filament. The chamber was made entirely of glass, by the joints being fused, and the small platinum wires were sealed in the glass, and pass into the chamber, just as is shown in my Patent No. 223,898 (McKeesport suit). V., 3128.

INVENTION INVOLVED:

"The discovery I made was that a fine filament of carbon, under the conditions I had, did not disintegrate to any extent. That was the discovery as set forth in my patent, but the patent has also, in addition, some invention as well as discovery; in other words, it requires invention to carry out the discovery which I made." IV., 2558, **10231.**

LAMP CHAMBER:

In October, 1879, we made lamps of paper carbon, and carbons of common sewing thread, placed in a receiver made entirely of glass, with the wires sealed therein by fusion, and the whole exhausted by a Sprengel mercury pump to nearly the one-millionth of an atmosphere (Interference Record). V., 3013.

My impression is that the first vacuum bulb for an incandescent conductor that would hold its vacuum was made in June or July, 1879. This was made entirely of glass, with the conducting wires sealed therein, and the

LAMP CHAMBER—(*Continued*):

vacuum obtained with a Sprengel pump. A platinum conductor was used with this lamp (Interference Record). V., 3014.

The paper horseshoe carbon lamp in evidence with the all-glass globe was made some time in December, 1879. The great advantage of this form and kind of lamp chamber over all previous attempts at lighting by the incandescence of carbon is that the incandescent conductor is placed in a chamber made entirely of glass; the wires forming the leading-in conductors pass from the exterior to the interior of the chamber, and are sealed by fusion of the glass where they pass through it. Hence these glass chambers, when exhausted to high vacuum, preserve the exhaustion constant, and thus provide the all-essential condition of high economy and durability of the thin filament necessary to use in order to obtain high resistance, permitting the economical subdivision of the electric light. All prior attempts have failed, because the chamber was not composed of glass, but of glass, and metals, and materials not having the same co-efficient of expansion as the glass, so that the air was not excluded. Hence most inventors have used a supposably inert gas in the chamber at atmospheric pressure, and the leading-in wires have not been passed through the glass and fused into it, which is an essential feature. The form and size are very convenient, it being small, light, portable, durable, and admits of radiating light in all directions, so that practically none is lost. Its size is such that it contains very little air, permitting it to be quickly and economically exhausted from the globe, and the whole lamp is so light that it can be used on present gas chandeliers in great numbers (Interference Record). V., 3025.

The substitution in the Sawyer-Man patent of the glass base for the metallic one (as it stood in the application filed) in no way does away with the objections to a separable lamp chamber, for the same difficulties of maintaining a vacuum would still exist. The glass base performs no new functions not fulfilled by the metallic base, and to-day all practical incandescent lamps are made with the all-glass lamp chamber. I see no advantage scientifically in a glass base, and commercially a metallic base would be very much easier brought into the required form. As a vacuum must be maintained by some substance at the junctures, the difference as to glass or metal would be immaterial. The chamber is made up of two parts; of glass, and some material between the joints to prevent leakage (McKeesport suit). V., 3097-8.

So far as avoiding oxidation, as stated in the Sawyer-Man patent, the metal base would be better than glass, as it would actually take up oxygen that might be left in the lamp. Regarding short circuiting, the same cementing material which is now used around the electrodes could be used to insulate the same from the metal. If such cementing material failed to prevent short circuiting, it would also fail to maintain the vacuum (McKeesport suit). V., 3099.

LAMP CHAMBER—(*Continued*):

A chamber "made wholly or entirely of glass" does not mean a chamber cemented or held together by a material for the purpose of preventing the joints leaking. In such a chamber there would always be leakage, which would render the excessively fine filament necessary for commercial subdivision impracticable. Were this class of lamps with this chamber, as shown in the patent of Sawyer-Man, the only means known to-day, lighting by incandescence with filaments of carbon could not be a commercial success. The chamber must be really and truly made wholly of glass, through which the platinum wires are passed and sealed thereto by fusion, the platinum having the same co-efficient of expansion as the glass itself. The lamp chamber made with separate parts would be wholly of glass if there was nothing between the joints, but in that case you could not maintain the vacuum. Patents issued to me, Nos. 223,898, of January 27th, 1880, and 227,229, of May 4th, 1880, describe lamps having chambers made entirely of glass, and contain subject matter showing the advantages of a chamber made entirely of glass, in contradistinction to one made with joints (McKeesport suit). V., 3099-3100.

The expression "lamp chamber made wholly or entirely of glass and hermetically sealed" in incandescent lighting means wholly of glass and all joints in the act of manufacture being sealed by fusing the glass. Hermetically sealed, as applied to the modern art of incandescent lighting, has probably a different meaning than when applied to canning fruit and such things. It means sealed in such a way as to maintain its vacuum continuously for any length of time. I know of no means whereby this can be done except by a fusion of the glass through which the platinum electrodes having the same co-efficient of expansion pass. A chamber made wholly of glass might be made in two parts and ground together, but this would not maintain a vacuum. If wax or other material were put into the joint it would be hermetically sealed in a fruit jar sense, but not in the sense in which the term is used in incandescent lighting, where, owing to the extreme minuteness of the incandescent conductor and the quantity of carbon, an extremely stable vacuum must be continuously maintained. In endeavouring to get a high resistance lamp by the use of platinum coiled, I arrived at conditions gradually wherein I was enabled to get an enclosing globe entirely of glass all fused together through which the platinum wires passed (McKeesport suit). V., 3123.

The moment that I had apparatus and means and methods whereby I made a chamber wholly of glass, and with the McLeod gauge on the Sprengel pump had determined that it held a vacuum continuously, I knew that I could make the hair-like filament permanent, provided the filament itself could be made sufficiently homogeneous (McKeesport suit). V., 3124.

If the lamp shown in the Sawyer-Man patent (317,676) had ever been intended to be sealed by fusing the glass together, it could not by any possible stretch of the imagination have been made as set forth in Fig. 5. In Fig. 5 there is a ground joint seal, and the caps would have to contain

LAMP CHAMBER—(*Continued*):

some unctious substances, as described in the Sawyer-Man patents, to maintain a vacuum even for an hour. Such lamps would not be useful or commercially made with such chambers (McKeesport suit). V., 3126-7.

The lamps made by the Consolidated Company, known as the Sawyer-Man lamps, are made entirely of glass, by the joints being fused and the small platinum wires sealed into the glass and passing into the chamber, just as is shown in my Patent No. 223,898 (McKeesport suit). V., 3128.

LAMP INCANDESCENT:

My first carbon electric lamp, if it may be called an electric lamp, was a piece of carbonized paper, about an inch long, one-sixteenth of an inch broad and six or seven thousandths of an inch thick, the ends of which were secured to clamps, which clamps formed the poles of a battery. This carbon on being brought to incandescence, oxidized immediately. This was in 1877. The first lamp in vacuo consisted of two clamps forming the poles, between which was placed and clamped a piece of carbonized paper. This was exhausted as far as possible by our air pump, and the carbon brought up to incandescence, after the air due to the first heating had been pumped out. The first experiment was tried in the open air. This was in 1877, probably September or October (Interference Record). V., 3043.

In October or November, 1878, the lamp which I experimented with consisted of a piece of carbonized paper coated with lamp-black and tar, carbonized, placed in the clamps connected to the circuit, and placed under the bell jar of the vacuum pump. Besides paper we also used broom corn. The carbons were about one thirty-second of an inch in diameter and one or two inches in length. The carbons were straight. We could not make the carbon stand, though we had potassium and sodium in the chamber of the pump. The current used was four or five webers (Interference Record) V., 3055-7.

My paper carbon lamp made in October, 1879, had a carbon about a thirty-second of an inch wide, six or eight thousandths of an inch thick, and about two and a half to three inches in length, and was bent into the form of an arch before carbonization. It had thickened ends, and there was a section of platinum interposed in the conductor between the copper and carbon. The height of the arc after being put into the lamp was about an inch or an inch and an eighth. The resistance of the whole carbon was probably 125 ohms cold, and perhaps 75 ohms at sixteen candles. The lamp was exhausted to the one-millionth of an atmosphere, and was raised in luminosity as high as 30 or 40 candles, at which it was kept for more than half an hour, and afterwards burned at from 12 to 16 candles for over one hundred hours continuously (Interference Record). V., 3059-61.

LAMP, INCANDESCENT—(*Continued*):

I have examined the lamps sold by the Consolidated Company, known as the Sawyer-Man lamps. They are almost precisely the same as our own lamps. The carbon filament was made of bamboo, as I ascertained by microscopical examination. The only difference was that the lamps were "flashed" by the deposition of carbon on the surface of the original filament. The lamp chamber was made entirely of glass, by the joints being fused, and the same platinum wires sealed in the glass and passing into the chamber, just as is shown in my Patent No. 223,898 (McKeesport suit). V., 3128.

Incandescent lamps had been proposed more than a quarter of a century previous to my taking the subject up, but no material advance had been made in their production, and the correct principle upon which to build them had not been discovered. The conditions of use of a practicable lamp had not been predetermined, nor had any system been devised, whereby practicable lamps of small unit candle-power could be used to supplant gas as a general illuminant. The lamp should give the same amount of light as the gas jet, should be durable, capable of being handled by the public, cheap to manufacture, and remain incandescent and stable for a great length of time. Each lamp should be independent of every other, although on the same circuit, and the light should be produced economically enough to compete commercially with gas (McKeesport suit). V., 3129-30.

It would be impossible to make a practicable commercial lamp according to the description and drawings of the Sawyer-Man Patent No. 317,676 (McKeesport suit). V., 3138.

A lamp made according to the Sawyer-Man patent (No. 317,676), filled with nitrogen gas, could be brought to incandescence by the application of an electric current; but, if brought up to the same degree of incandescence as the regular incandescent lamp now sold throughout the country (*i. e.*, about 240 candles per electrical horse-power), it would not last for a period of 24 hours (McKeesport suit). V., 3139.

We are enabled by careful manipulation to produce lamps much better than we were able to make in 1880, although some of the 1880 lamps were far superior to some of the lamps now made from the same material. Perfection in details of manufacture also improve the efficiency. The art of manufacturing is constantly improving in the sense that in a lot of 100 lamps there will be a less number broken in the first hundred hours than in a lot of 100 made the year previous (McKeesport suit). V., 3142.

If the incandescent conductor of textile or fibrous matter is a good one, and made from proper material, and properly exhausted, and the chamber is hermetically sealed by the fusion of the glass, so that the whole of the chamber shall be made of glass, through which the platinum wires are sealed, and the vacuum is high and stable, such a lamp would be, if included in an electric circuit, a commercial success (McKeesport suit). V., 3142-3.

LAMPS, SEMI-INCANDESCENT:

In lamp shown in Patent 224,329 provision was always made for the passage of a continuous current, the light given being partially due to an arc and partially to electrical incandescence. Werdemann's, Joel's and some of Sawyer's lamps act somewhat on this principle (Interference Record). V., 3011.

LEADING WIRES:

In my paper carbon lamps the leading-in wires to within a quarter of an inch of the glass are formed of copper. These copper wires afe secured by soldering platinum wires which are passed through and fused in the glass. Upon the extremity of these wires, within the chamber, are clamps which serve to clamp the broadened end of the filament of carbonized paper. This broadened end is essential to permit of a proper clamping and electrical contact, as the increased conductivity of the broadened end prevents it becoming incandescent. If the filament of carbon were of the same size throughout, lamps of this character would be rapidly destroyed by the formation of small arcs at the point of clamping, which throwing out the vapor of carbon and platinum within the vacuum, would permit the formation of a large arc between the two leading-in wires, and the lamp would be instantly destroyed. The necessity of using platinum to seal in the glass is that of all metals its co-efficient of expansion is nearest to glass, hence the glass and platinum will expand and contract together under differences of temperature, and thus prevent leakage of air or cracking of the glass chamber (Interference Record). V., 3025 6.

One reason why one does not care to make series lamps of a very low resistance is because this necessitates too large leading wires. "Of course, in the last few years the glass blowers have got very expert, and they are enabled to seal larger wires into the glass than we could in the olden days." IV., 2589, **10354.**

MULTIPLE ARC:

As to my connection, as a discoverer, with the question of the relation that exists between the size and proportions of the burner of an incandescent lamp, and the character of the conductors employed to convey the current to the lamps when in multiple arc, "there were two ways of doing incandescent lighting which were known to all men. One was by series: one was by multiple arc." Every one seemed to be working on series. I concluded that that was the wrong principle, and I concluded that the multiple arc was the best principle, and I so appreciated that that was the best principle of the two that I kept at it until I had produced a lamp which was of suitable form for work in multiple arc. I did not discover the law of Ohm or its application to that particular system, but there were two systems open to all men, and I chose the multiple arc system and I worked at it until I got the conditions which permitted utilizing that particular system. IV., 2569-70, **10275-7.**

MULTIPLE ARC—(*Continued*):

I first arranged lamps in multiple arc on October 5, 1877; think their resistance was very low. It might have been two ohms or less. The burners were made of little pieces of silicon smaller than the head of a pin. IV., 2576-7, **10301-5.**

Believe that I first actually arranged lamps, with carbon burners, in multiple arc about November, 1879; think this was done before the date of application for the patent in suit. IV., 2587, **10345.**

"The copper question is very serious for multiple arc lightihg, even in short distances, but is not a question at all in series lighting." IV., 2589, **10356.**

I think I was the first to use the multiple arc system in connection with a practical lamp which permitted the use of such a system. IV., 2603, **10410.**

Do not know whether I was the first to recognize the advantage of placing incandescent lamps in multiple arc. "I believe that I was the first man to make multiple arc lighting, with incandescent lamps, practicable and commercial." IV., 2604, **10415.**

PATENT IN SUIT:

sets forth the necessity of a lamp of high resistance and small radiating surface in an all glass globe, with wires sealed in by fusion, the globe being exhausted to a very high vacuum (Interference Record). V., 3013-4.

describes a lamp chamber made wholly of glass, and sets forth the different advantages of chambers made entirely of glass over those made with joints (McKeesport suit). V., 3100.

I appreciated the fact that the method shown in the Sawyer-Man patent (No. 317,676) was defective, but I did not appreciate that fact until I had experimentally determined that the only possible means whereby a continuously stable vacuum could be obtained was the use of a chamber made entirely of glass, and when this became certain to my knowledge I applied for the Patent No. 223,898 (McKeesport suit). V., 3143.

Working in accordance with the instructions contained in the patent in suit, I would use a mandril upon which to coil a spiral and would withdraw it before carbonization. These two steps are self-evident. The patent tells one to wind a spiral; the human mind can conceive of no other way to wind it except on a mandril. IV., 2554, **10215-6.**

"necessarily would more fully set out descriptively the tar-putty lamps" (than the thread lamps), "as there was more manipulation in this character of lamp." IV., 2561, **10242.**

RADIATING SURFACE:

In November or December, 1878, what we desired, and had decided upon as being the only possible solution of the subdivision of the electric light, was lamps of high resistance and small radiating surface, so as to be capable of being worked in multiple arc commercially. We knew from our previous experiments that we could get the requisite resistance and small radiating surface necessary for a commercial use of the light, by means of carbonized paper or wood. The great point desired was a lamp of high resistance and small radiating surface, and it did not much matter whether it was of carbon or of platinum. When we had obtained a very high vacuum by means of the Sprengel pump, we had reached the conditions under which the carbon, though small in mass, was stable (Interference Record). V., 3012-3.

Between November or December, 1878, and October, 1879, I was endeavoring to obtain a lamp of high resistance—for instance, 100 ohms—with small radiating surface; the former to permit of economical subdivision, the latter to permit of economy in the use of electric power. Coiled platinum or platinum iridium wire was used in these experiments (Interference Record). V., 3014.

With small radiating surface less energy is required to produce a candle-power than on a larger surface. Again filaments of carbon, being small in mass, conduct very little heat from the incandescent conductor to the clamps and supports, hence no special appliances are needed to get rid of the heat of conduction such as are employed in the Sawyer lamps (Interference Record). V., 3023.

In order to be suitable for use in an incandescent lamp, the carbon must be aggregated together in such a manner that the total weight of the carbon between the two electrodes shall, with a given radiating surface, be far less than if the carbon was perfectly dense; the interstices of the carbon may be large or small (Interference Record). V., 3092.

RESISTANCE:

What we desired in November or December, 1878, and had concluded as the only possible solution of the subdivision of the electric light, was a lamp of high resistance and small radiating surface, so as to be capable of being worked in multiple arc commercially, and our calculations showed us that the lamp must have at least 100 ohms resistance to compete successfully with gas; otherwise, if the lamps were of low resistance, the cost of the main conductors would be so great as to render the system uncommercial. Our efforts to obtain incandescent conductors of high resistance and small radiating surface were impeded by the fact that we could not make them last for any length of time in the best vacuum obtainable in our common air pumps. In October, 1879, using the Sprengel pump, we obtained a very high vacuum, and found that our filaments of carbon, although excessively fragile owing to their small mass, had a smaller radiating surface and higher resistance than we had hoped (Interference Record). V., 3012-3.

RESISTANCE—(*Continued*):

Between November or December, 1878, and October, 1879, I was endeavoring to obtain a lamp of high resistance—for instance, 100 ohms—with small radiating surface: the former to permit of economical subdivision, and the latter to permit of economy in the use of electric power. Platinum and platinum iridium wire was used to obtain this result. In many of these lamps the major portion of the wire was coiled so as not to radiate light, to the end that the lamp might have a high resistance (Interference Record). V., 3014.

The average resistance of the paper carbon lamps made in 1879, was about 100 ohms hot; some of them were as high as 1,000 ohms (Interference Record). V., 3030.

In lamps to be run in series, where large currents are necessary, the endeavor is to reduce the resistance of the incandescing conductor as much as possible, in contradistinction to the multiple arc system, in which the object is to increase the resistance as far as possible (McKeesport suit). V., 3120.

Concerning the principle that, by increasing the resistance of a translating device which was to be used in multiple arc, an economy in the conductors could be effect, "I think I was one to appreciate that principle so highly as to stick to it until I had produced a means whereby it could be utilized." IV., 2568, **10271.**

When I first began my experiments on incandescent lighting "I started on the wrong track; I started on series." After experimenting a long while on the one system, I gradually got the idea that that was the wrong system, that the multiple arc system was the best; and then I found that in the lamps of low resistance the cost of copper would be too much, and then I appreciated the fact that if the lamp could be made of high resistance I could diminish my copper, and I kept right on experimenting and trying to get a lamp of high resistance, so that I could use this multiple arc system. IV., 2573-4, **10292-3.**

From knowledge acquired by my experiments "it gradually dawned upon me" that lamps of low resistance would require too much copper, and that copper could be saved by increasing the resistance of the lamp. This was some time in the early part of 1879. IV., 2574, **10294-6.**

I first arranged lamps in multiple arc on October 5, 1877. I think their resistance was very low. It might have been two ohms or less. The burners were made of little pieces of silicon, smaller than a pin head. IV., 2576-7, **10301-5.**

"There are two ways of getting high resistance in the lamp. One is by making the filament thin and long, and the other is to make it of a kind of

RESISTANCE—(*Continued*):

carbon that is not solid, whose structural arrangement is cellular. This is the case with organic carbon. The carbon itself may be as dense as the gas retort carbon, but the resultant product of the decomposition by heat is such that it retains the original cells due to its vital principle, and these are one of the aids to increase the resistance of the lamp." IV., 2587-8, **10348-9.**

In my early experiments with platinium lamps I was after a high resistance, as set forth in my Patent No. 227,229. IV., 2600, **10397-8.**

The resistances of the lamps given on pages 219,221 and 223 of Batchelor's Note Book No. 52 are cold resistances, and are fair samples of the average resistances of lamps made for the public exhibition at Menlo Park on January 1, 1880. The hot resistance of these lamps was probably somewhat less than 100 ohms. IV., 2607, **10425-6.**

In my testimony in the interference proceedings, in stating that "our calculations (in November or December, 1878) showed us that the lamp must have at least one hundred ohms resistance to compete successfully with gas," I referred to the erecting of the first central station and competing with gas in New York. If I had referred to a small plant it would have called for a low resistance lamp, because it is not necessary in a small installation to have so high a resistance lamp. It refers to distribution on a large scale—on the scale which I intended and afterwards carried out in New York. The price of gas was an element in the calculation. The calculations were made for a lamp which we were trying to get but did not have. IV., 2608, **10429-32.**

If you want to compete with gas on a large scale, of course you must go over a large area and use a large number of lights, and therefore want a high resistance. If, on the other hand, you want to light a mill, or large store locally, it is not necessary to have such a high resistance, even with lamps in multiple arc. IV., 2609, **10436.**

In 1878, in making my calculations of the resistance which the lamps should have for lighting New York, I contemplated dividing the city into separate districts of from half to three-quarters of a mile square. IV., 2610, **10438.**

As to the resistance of the lamps required for central station lighting: "In 1878 we had not got there; we thought we knew what we wanted, but had not got it." IV., 2612, **10447.**

There is a change in the resistance of filaments after they have been carbonized in the furnace when the current is passed through them. IV., 2614, **10454.**

RESISTANCE—(*Continued*):

Thinks that he had a method for measuring the resistance of lamps when hot in January, 1880. Thinks that the hot resistance of lamps made late in 1879 was about fifty-seven per cent. of their resistance when cold. To-day the hot resistance of bamboo filaments is about sixty-seven per cent. of their cold resistance. IV., 2614-5, **10456-8.**

RESISTANCE, SPECIFIC:

Paper carbon, free from adulterations, compact and well carbonized, will have a high specific resistance (Interference Record). V., 3091.

Paper and other organic carbon has the desirable quality of high specific resistance, owing to its cellular structure (Interference Record). V., 3091.

All kinds of carbon, except, perhaps, the diamond, are the same, their different appearances being due to their structural arrangement. Thus hard gas retort carbon and paper carbon are the same kind of carbon, their difference consisting in their structural arrangements. Paper carbon, wood carbon, and all carbon derived from vegetable organic matter of cellular formation, when carbonized are very porous, hence the resistance to the passage of the current through a square millimeter section and one inch long, would be very much greater than if the same was made of hard retort carbon. As high resistance is desirable to make a commercial incandescent lamp, paper and other organic carbon has the desirable quality, owing to its cellular structure giving such high resistance. High resistance to the passage of the current allows of commercial subdivision, and this quality organic carbon is possessed of (Interference Record). V., 3091-2.

SEALING:

In incandescent lighting, "hermetically sealed," means sealed in such a way as to maintain a vacuum continuously for any length of time. I know no way whereby this hermetically sealing can be done except by fusion of the glass, the chamber being made wholly of glass, through which the platinum electrodes, having the same co-efficient of expansion as glass pass. A chamber made wholly of glass might be made in two parts and ground together, but this would not maintain a vacuum. If some material like wax were applied to the joints, the chamber would be hermetically sealed in a fruit jar sense, but not in the sense in which the term is used in incandescent lighting (McKeesport suit). V., 3123.

Sealing the glass by fusion is not an obvious thing. It took me a long while to reach, by experimentation, the condition which caused me to appreciate that fact. I appreciated the fact that the method shown in the Sawyer-Man patent (No. 317,676) was defective, and when I had experimentally determined that the only possible means whereby a continuously stable vacuum could be obtained was by the use of a chamber made en-

SEALING—(*Continued*):

tirely of glass, I applied for the Patent No. 223,898. Such things are never obvious—for instance, the telephone and phonograph, two excessively simple things, performing great results, were not obvious to men well skilled in the art, who knew all the conditions necessary to produce such instruments. In science those things which are the most simple and most conspicuous seem to be hidden the longest. Their very conspicuousness seems to hide them (McKeesport suit). V., 3143 4.

One reason why one does not care to make series lamps of a very low resistance is because this necessitates too large leading wires. "Of course, in the last few years the glass blowers have got very expert, and they are enabled to seal larger wires into the glass than we could in the older days." IV., 2589, **10354.**

SERIES:

When I first began my experiments on incandescent lighting "I started on the wrong track. I started on series." IV., 2573, **10292.**

SHAPING:

I do not conceive how it is possible to rub down a paper carbon made out of blotting paper (as Mr. Man says), unless it is very large, such as an eighth of an inch square, and then I judge it would be very difficult. I do not see the necessity of it, as any thickness of paper could have been used and any desired shape. It is not an easy matter to rub down blotting paper before it is carbonized (Interference Record). V., 3032.

In the Sawyer-Man original application (Patent No. 317,676) there is no indication as to whether the material is to be cut and shaped before carbonization or not. The patent as issued contains a somewhat general description, saying that the material is conformed to the desired shape and size, and then carbonized, while confined in retorts in powdered carbon. It gives no description as to how it is to be cut (McKeesport suit). V., 3118-9.

STABILITY:

When in our experiments in November or December, 1878, using the vacuum then obtained with our common air pump, we made carbon in such a form as to have a small mass and high resistance, it would last but a few minutes. After we had, in October, 1878, secured, by means of the high vacuum obtainable with the Sprengel pump, the necessary conditions, the carbons were stable, though small in mass and filamentary (Interference Record). V., 3012-3.

In December, 1879, Mr. Sawyer stated in a communication to the press that a paper carbon lamp would not last twenty minutes, even in a perfect vacuum. Now as Mr. Sawyer did not get anywhere near a perfect

STABILITY—(*Continued*):

vacuum, the results obtained by Sawyer-Man were no doubt dismal failures (Interference Record). V., 3036.

Concerning the lamps made in December, 1879, and January, 1880, we have never been able to find out what put an end to the lamp. No one to-day knows the reason why the filaments fail. They keep good up to a certain time and then suddenly break. Oxidation is not the cause, as I have seen lamps run several hundred hours and still maintain their candle-power within a few per cent. and then the filament would suddenly break—actually break. IV., 2597, **10385-6.**

Also see Discovery.

SUBDIVISION:

In November or December, 1878, what we desired, and had concluded as the only possible solution of the subdivision of the electric light, was lamps of high resistance and small radiating surface, so as to be capable of being worked in multiple arc commercially, and our calculations showed us that the lamp must have at least 100 ohms resistance to compete successfully with gas, for, if the lamps were of low resistance, the cost of the main conductors would be so great as to render the system uncommercial. What is meant here by a subdivision of the electric light is that many thousand lamps could be put upon a single circuit, and be entirely independent of each other. The conditions which made economical subdivision of the electric light possible, were high vacuum in a receptacle in which no deterioration or lowering of the vacuum occurred to destroy the carbon. These experiments resulted in the lamp and various modifications and forms set forth in the patent in suit (No. 223,898) (Interference Record). V., 3012-14.

About December 3d, 1877, we were trying to subdivide the electric light into a number of small burners, where the circuit was closed by solid conductors; we used silicon and boron, because they did not oxidize like carbon and lasted longer (Interference Record). V., 3020-1.

I ascertained by experiment in 1876 and 1877, that paper carbon had a proper resistance to admit of subdivision in multiple arc, and I was perfectly aware when I made the first incandescent lamp that organic carbon was the proper kind to use, as with a small mass it had a high electrical resistance (Interferance Record). V., 3093.

When in October, 1877, I placed the carbon burner in a high vacuum, I ascertained and obtained the conditions under which the conductor could be made small enough to allow of commercial subdivision (Interference Record). V., 3094.

The subdivision of the electric light into small units comparable with that of the ordinary gas-jet, was what I thought was required, in 1878, when I

SUBDIVISION—(*Continued*):

took up actively the subject of electric lighting. The general scientific opinion was that this could not be done. Even after it had been announced in the public press, in 1879, that it had been accomplished by me, the statement was discredited, and was pronounced by many eminent scientific men, both in this country and abroad, to be an impossibility. A committee was appointed by the English Parliament to examine the general subject, and they called before them as witnesses nearly all the prominent scientific men in England, all of whom, with the exception of Prof. Tyndall, testified that, in their opinion, the subdivision of the electric light was an impossibility. Mr. Tyndall said he would hardly go so far as that—he would not say it was impossible, but he would not like to undertake the solution of the problem (McKeesport suit). V., 3129.

VACUUM:

In October or November, 1878, a large number of paper carbons, made from tissue and other kinds of paper, coated with lamp-black and tar, rolled into the form of a knitting-needle and carbonized by heat, were included in electrical circuits and brought up to incandescence in vacuo (Interference Record). V., 3009

In November and December, 1878, we were blocked in our endeavors to obtain incandescent conductors of high resistance and small radiating surface by the fact that we could not make them last for any length of time in the best vacuum obtainable with our common air pump. But when we had procured a Sprengel mercury pump, and ascertained that we could get exceedingly high vacuo, it occurred to me that a filament of carbon could be made to stand in the sealed glass vessels which we were using, exhausted to a high vacuum, and in October, 1879, we made lamps of paper carbon and carbons of common sewing thread, placed in a receiver made entirely of glass, with the wires sealed therein by fusion and the whole exhausted by a Sprengel pump to nearly one-millionth of an atmosphere, and these filaments of carbon, though excessively fragile owing to their small mass, had a smaller radiating surface and a higher resistance than we had hoped: we had reached the conditions where, notwithstanding the carbons were small in mass and filamentary, they were stable. These conditions were high vacuum in a receptacle in which no deterioration or lowering of the vacuum occurred to destroy the vacuum (Interference Record). V., 3012-4.

About September or October, 1877, experiments were made with an electric lamp having paper carbon burner brought to incandescence in vacuo. The apparatus was attached to an air pump and exhausted, but on account of poor vacuum, we could not make the carbons last more than a few minutes (Interference Record). V., 3018.

High vacua render the carbon horseshoe practically stable, and at the same time economical in the use of electricity, as practically all the energy is lost by radiation, and none by conduction. My experiments have shown

VACUUM—(*Continued*):

that if a carbon horseshoe is placed in an atmosphere of nitrogen at the atmospheric pressure, which is the method adopted by Mr. Sawyer in his lamp experiments, it requires nearly twice as much electricity to bring the horseshoe up to the same candle-power as it does when the horseshoe is in a high vacuum. Heat is lost by conduction through the gas to the enclosing globe, from which it radiates invisibly. Hence my lamp is, I believe, the first one ever produced that was commercially available for competition with lighting by gas, and of great utility (Interference Record). V., 3022-3.

The paper carbon lamp was exhausted by means of a double glass pump, one part of the pump being known as a Geissler pump and the other as a Sprengel pump, in which mercury is used in the well-known manner. The vacuum was carried beyond the millionth of an atmosphere (Interference Record). V., 3027.

In the 1877 lamp, in which we used a vacuum, we got two and a half millimeters on the gauge, showing that we had within two and a half millimeters of a perfect vacuum (Interference Record). V., 3052.

In August, 1879, we had a pump that would produce a vacuum up to perhaps the hundred thousandth part of an atmosphere: this was the first pump by which a partially successful vacuum could be obtained (Interference Record). V., 3071-2.

My impression is that generally the carbon would not last more than four or five hours at 15 candles, when the mercury column showed a vacuum of only about a millimeter (Interference Record). V., 3073.

In a commercial sense it is my opinion, which results from my experiments, that it is essential to have a high vacuum in the lamp chamber (Interference Record). V., 3082.

When in October, 1879, I placed the carbon conductor in a high vacuum, I ascertained and obtained the conditions under which the conductor could be made small enough to allow of commercial subdivision (Interference Record). V., 3094.

A stable vacuum could not be maintained in the separable lamp chamber shown in the Sawyer-Man, for between the two parts, in spite of any substance placed there to prevent leakage, the air would enter and spoil the vacuum (McKeesport suit). V., 3097-8.

The old means of obtaining a vacuum were so crude, as compared with the modern method, that not only could not a sufficient degree of exhaustion of the air be obtained, but, even with the exhaustion obtained, it was not continuous, owing to the leakage at the joints of the apparatus. By old means I mean the mechanical air pump and bell jar and other devices (McKeesport suit). V., 3124.

EDISON, Thomas A.

VACUUM—(*Continued*):

The moment that I had apparatus, and means, and methods whereby I made a chamber wholly of glass, and with the McLeod gauge on the Sprengel pump, had determined that it held a vacuum continuously, I knew that I could make the hair-like filament permanent, provided the filament itself could be made sufficiently homogeneous (McKeesport suit). V., 3124.

If in a vacuum we can obtain eight lamps of sixteen candles each per horse-power, in an atmosphere of nitrogen at atmospheric pressure we should not get more than one lamp, of sixteen candles, per horse-power, and in an atmosphere of hydrogen, no light at all (McKeesport suit). V., 3125.

I first got a Sprengel pump in the middle of 1879. IV., 2585, **10337.**

I think I first knew of a better pump than the ordinary mechanical air pump, and first heard of the Sprengel pump about July, 1879. IV., 2600, **10399.**

ENGLISH DECISIONS:

CLAIMS OF EDISON'S BRITISH PATENT:

Provisional specification dated November 10, 1879. Final specification dated May 10, 1880.

"(1) An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires as set forth.

(2) The combination of a carbon filament within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted, for the purposes set forth.

(3) A carbon filament or strip coiled in such a manner that only a portion of the surface of such carbon conductor shall radiate light as set forth.

(4) The method herein described of securing the platina contact wires to the carbon filament, and carbonizing the whole in a closed chamber, substantially as set forth" (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 303-4, **1212-13.**

COMMERCIAL SUCCESS:

"Now, with reference to Mr. Edison's Patent, which is a patent of the 10th May, 1880, there is one fact, which is either admitted or beyond controversy in this case, and that is, that before the date of the specification in question, no good and efficient lamp was made or known." Butt, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). I., 280-1, **1120-1.**

"There is no evidence that a single lamp made under any one of the specifications or provisional specifications we have referred to ever gave a ray of light. The rapidity with which the patents succeeded one another in 1878 and 1879 shows how keen was the race for the production of a good incandescent electric light, and the fact that no one of the inventors in question is shown ever to have succeeded seems to be strong evidence that every one of the ingenious apparatus which they devised resulted in failures." Bowen and Fry, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 311, **1242.**

Note. The specifications and provisional specifications above referred to are those of King, Roberts, Van Choate and Pulvermacher, and all of those of Lane-Fox.

It appears to be proved that every successful lamp since 1879, which is available for multiple arc lighting, has employed a filament. Bowen, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 342, **1368.**

FILAMENT OF CARBON:

As to the words "a carbon filament" in the 2d claim of Edison's British patent: "I hold them to mean any carbon filament, however made, which possesses certain qualities or properties mentioned in the specification, or necessarily resulting from the description there given. To answer that description the carbon filament must, I think, possess flexibility and resilience. It must be of small cross-section, offering a high degree of resistance to the passage of the electric current, and it must present but a small surface from which radiation of light can take place." BUTT, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). I., 282, **1127.**

Dr. Odling, a witness for defendant, says that "Mr. Edison first applied the word filament to the conductor of an incandescent lamp." BUTT, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). I., 284, **1134.**

As to the meaning of the words "carbon filament" in claim No. 2: "It is said, that in the multitude of counsellors there is wisdom, but when these counsellors turn out to be equally divided in opinion, and when it turns out that the only opinion on which they agree is that they agree to differ, I do not see how the Judge derives very much benefit or advantage from their evidence. Such is the case here. * * * In these circumstances I must draw such a conclusion on the point as my own uninstructed mind will enable me to arrive at. To my mind, it does seem to me that a carbon pencil or rod is a very different thing from a carbon filament. It is difficult to express exactly the whole process of reasoning by which I come to that conclusion. It seems to me to carry one a long way on the road to that conclusion to say that a rod or pencil is a rod or pencil, and a thread is a thread. There are, however, certain differences which are not difficult to explain. It appears to me clear that one of these differences between Mr. Swan's conductor and Mr. Edison's conductor is this: Mr. Edison's conductor possesses a smallness of cross-section combined with other properties which Mr. Swan's does not. Mr. Edison's conductor possesses a degree of flexibility which, to my mind, is not even approached by Mr. Swan's. * * * Now, I cannot help thinking that at the time in question, not in January, 1880, but at an earlier period before Mr. Edison's specification, had Mr. Swan known of the various advantages of Edison's carbon filament as used, his lamp would never have contained a straight rod fixed at each end, and by straight of course I mean lying evenly between the two points of junction, a straight rod so fixed to the ends of platinum wires. Moreover, I think that there is no evidence to show that before Mr. Edison's specification he knew how to make a carbon conductor of anything like so small a cross-section which would answer to the other requirements stated." BUTT, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). I., 290-1, **1157-63.**

NOTE. The references to Swan are to his experiments on carbon lamps before date of patent in suit.

FILAMENT OF CARBON—(*Continued*):

"The first time that I can find Mr. Swan's conductor spoken of by him as a filament is in his Final Specification of the Patent which forms one of the matters in this suit, and that is under the date of 1st July, 1880, Mr. Edison's Final Specification being some seven or eight weeks prior to that. He chooses to use it. What he read and what he did not read is unknown to me, but having at all events, if he had chosen to use it, the advantage of the knowledge conveyed to the public by Mr. Edison's specification, it is true we do find Mr. Swan some weeks later calling his carbon conductor a filament. Now, a rose does not smell any sweeter for being called a rose, and the fact that Mr. Swan did subsequently call that rod a filament does not at all convince me that it was properly so called." One of the defendant's witnesses testifies that the word filament is applied by electricians to all manner and kinds of carbon conductors in incandescent lamps. "That may be so. Words often become, when applied to particular trades or sciences, twisted from their original meaning." A flower has been produced and I have been told that the part which holds and supports the anther is, in botany, called a filament, whatever its thickness. "So be it. It has acquired that name in botany just as these conductors have since, among electricians, acquired the name of filament, but I suspect it would be found they have acquired the name of filament since flexibility was introduced and rigidity was tabooed." BUTT, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). I., 291-2, **1164-8.**

"The evidence shows that at the date of the (Edison) patent the expression 'carbon filament' was new as applied to electric lighting." LINDLEY, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 335, **1338.**

As to Edison's carbon filament and the carbon rods in Swan's early lamp in evidence, "the two may be made to shade off into each other until it becomes impossible to draw the line sharply between them; but this does not prevent a man from perceiving the difference between the two types, or from adopting the one which succeeds in preference to the one which fails." LINDLEY, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 340, **1358.**

"The merits of a filament, as distinguished from a rod, are manifest. The filament or thread has an extremely small sectional area; it is flexible before carbonization, and resilient afterwards." BOWEN, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 342, **1367.**

Also see Invention Involved and Shaping.

FILAMENT OF TAR-PUTTY:

"* * * On the evidence before us, many of these lamps were shown to have run for a sufficient time to prove that they could not be considered failures in this respect;" that is, the lamps with the putty filaments are practically useful. COTTON, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 329, **1314.**

INFRINGEMENT:

"* * * I hold that, attributing the meaning I have to Claim No. 2 (of Edison's patent), there has been a clear infringement by the defendants of that claim." BUTT, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). I., 293, **1169.**

INVENTION INVOLVED:

"But as between the Swan and Edison, the difference is only between a rod and a filament: that is, a difference of degree and of degree only. * * * It is urged that a mere variation in the size of a part of a lamp is not the subject of a patent. It may well be that no patent could be sustained for the use of a filament of carbon alone; but when that filament is part of a combination which is useful, and replaces a rod in an earlier apparatus which was useless, we can see no reason why the new, useful combination may not be the good subject of a patent. It was strongly argued that the mere change of the size of a part of the combination cannot constitute a new manufacture so as to be the subject of a patent. In most instances this may be true, but the present case is peculiar. Two, and, so far as we have learned, only two, specimens of the earlier form of the instrument" (lamps made by Swan) "have been constructed, and in both of those a rod and not a filament of carbon had been adopted. Mr. Edison used the filament instead of the rod for a definite purpose, and by the diminution of the sectional area made a physical law subserve the end he had in view. The smallness of size, therefore, was no casual matter, but was intended to bring about, and did bring about, a result which the rod could never produce, and so converted failure into success. The point upon which Mr. Edison's instrument departed from Mr. Swan's was crucial, and the departure, though slight, had all the merits of a new invention, and produced a new apparatus." As to the three cases which "were cited to show us that a mere variation in the size of the carbon conductor will not constitute the good subject of a patent. * * * it does not appear to us that any of these decisions show, or tend to show, that the introduction into an old combination of a new shape of one of the old elements of that combination which invokes a law of nature, otherwise left on one side, may not be the good subject of a patent. For these reasons we are of opinion that the objection to the second claim fails." BOWEN and FRY, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 312-14, **1246-53.**

"I do not see any fact now brought before us which ought to induce the

INVENTION INVOLVED—(*Continued*):

Court to depart, or would justify the Court in departing, from the previous decision of the Court on the question of the invention" (Edison's patent of November 10, 1879), "being useful, and being good subject matter for a patent" COTTON, L. J., (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 326, **1304.**

As to Swan's lamp in evidence (made before date of Edison's patent), the evidence shows that it was a failure and that Swan had not got the key to success. "His own efforts to improve his lamp show that he was not thinking of filamentous incandescent carbons, but of other matters. Still his lamp did give light for a time, and was very near, though in my opinion, not quite an anticipation. It was, in truth, an unsuccessful experiment. I agree with Lord Justice FRY in thinking that the point at which Mr. Edison's instrument departed from Mr. Swan's was crucial, and the departure, though slight, had all the merits of a new invention and produced a new apparatus." LINDLEY, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 339, **1354-5.**

KING'S LAMP:

"Now, comparing this apparatus with the combination embodied in the second claim of Mr. Edison, we find a carbon conductor and a vacuum; but we find that the carbon was not required to be a filament—we find that it was placed in a receiver made not entirely of glass, but partly of glass and partly of the top of the mercury column, consequently that the leading wires were to pass, one through the glass and one through the mercury." BOWEN and FRY, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 307, **1228.**

Also see Commercial Success.

LANE-FOX'S PATENTS:

It is abundantly clear, from the different specifications of Lane-Fox, that he realized and knew the elements that were necessary in a good incandescent lamp—for example, the necessity of a high degree of resistance. But it is true that "when he comes to prescribe what he would use for the purpose of his invention, Mr. Lane-Fox nearly always seems to refer to metallic wire as the conductor, and not to carbon. He does mention in one or more of his specifications a carbon conductor. Then, as I understand the matter, like Mr. Pulvermacher, when he comes practically and finally to deal with the matter, he disclaims it and drops it out of his patent. Why? Evidently because he did not know how to make an efficient carbon conductor. The carbon conductor he describes he must have thought—and he says, in fact—was less desirable than the metallic, under all circumstances; and he did not know how to make one that would be better." BUTT, J. (High Court of Justice, in suit of Edison

LANE-FOX'S PATENTS—(*Continued*):

and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). L., 288-9, **1152-4.**

As to his specification of October 9th, 1878 (No. 3988): "That Mr. Fox's lamp had a great general similarity to the one now in use cannot be doubted; but the most suitable material known to him, and the only one he mentions, is an alloy of platinum and iridium, metals which, though of low conductivity (high specific resistance) as compared with many other metals, have a high conductivity (low specific resist. ance) as compared with carbon. He did not regard inclusion in a glass or any receiver as necessary, and when he did use such a thing he filled it with nitrogen gas. We have not carbon in the filament, not the glass receiver, and not the vacuum of Mr. Edison." As to Mr. Fox's next patent, dated October 12th, 1878 (No. 4043): "It is obvious that in the first form of conductor we have a metal and not a carbon conductor: in the second the resistance is raised, not by the reducing the carbon to a filament, but by the intermixture of a non-conducting material with a conducting one, or by the subdivision or extenuation of the conducting material by the mode of its application to the non-conductor. We miss, too, the vacuum which was to protect the conductor from all mechanical deterioration. In short, we have not the carbon filament nor the exhausted receiver of Edison." As to Mr. Fox's third patent of November 14th, 1878 (No. 4626), in our opinion the burner described in the provisional specification is nothing other than the second form of burner, which is described in the specification of October 12th, and not then filed: "There is no new light thrown on the inquiry by this provisional specification." Concerning Lane-Fox's provisional specification of March 20th, 1879 (No. 1122): "The conductor was to be enclosed in a globe from which not all gas, but, as we read the specification, any gas or matter capable of effecting a chemical change in the luminous bridge (burner), should be removed. It is evident that we have neither the carbon conductor for the filamentous form, nor the vacuum of Mr. Edison." Bowen and Fry, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). L., 309-11, **1233-41.**

Also see Commercial Success.

MULTIPLE ARC:

It appears to be proved that every successful lamp since 1879, which is available for multiple arc lighting, has employed a filament. Bowen, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). L., 342, **1368.**

NOVELTY:

"Now, with reference to Mr. Edison's patent, which is a patent of the 10th May, 1880, there is one fact, which is either admitted or beyond contest

NOVELTY—(*Continued*):

in this case, and that is, that before the date of the specification in question no good and efficient incandescent electric lamp was made or known." Butt, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson). L., 280-1, **1120-1.**

I have come to the conclusion that there is no ground for the assertion that Edison's patent has been anticipated, or, in other words, that it is not new. Butt, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). L., 292, **1168.**

"* * * I think there is reason for believing that it was Mr. Edison's patent which led back the world of electricians to the true path. * * * I think this patent constituted a new departure in electricity; * * *." Bowen, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). L., 343-4, **1372-3.**

PATENT IN SUIT:

As to the lamp described in Edison's British Patent of May 10, 1880, Sir Frederick Bramwell says in his evidence: "I find a vessel made entirely of glass containing a carbon filament attached to conducting wires, which wires are sealed through the glass. I find that this vessel is to be exhausted of its air to a very great degree, the patentee mentioning that the one-millionth of an atmosphere may be left. The patentee says that with a lamp of that construction light can be obtained by rendering the filament incandescent by means of an electric current. That is his account of the invention, and I adopt that account, and adopt it without the slightest hesitation, because it is not a matter which depends on my own judgment. It was accepted by all the scientific witnesses called by the defendants." Butt, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). L., 281, **1121-3.**

In support of the invalidity of Edison's patent, it has been said that "a carbon filament, when taken to mean that which I have held it to mean, is a description too vague and indefinite, or, to use the Solicitor-General's own words, too large. That is an argument to which I cannot accede, for I see no reason why a carbon filament having the properties mentioned in Mr. Edison's patent, and which the patentee tells the public how to make, may not properly be the subject of a patent, although it is capable of being made by methods and of materials other than those set forth in the specification. This observation certainly does not lose any of its force where the filament in question is not the thing patented, but only one of the several parts of a combination patented." Butt, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). L., 283, **1132.**

In support of the invalidity of Edison's patent, it has been said that "the specification is not such as would enable a competent workman to make

PATENT IN SUIT—(*Continued*):

the lamp. The plaintiff's witnesses have stated that in their opinion it would enable him to make the lamp. • • • I come to the conclusion that a sufficiently good lamp, for the purpose proposed I should say, may be made by a competent workman, from the description given in Mr. Edison's specification." BUTT, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). I., 284-5, **1133** and **1137.**

"Mr. Edison has in his specification given no definition of a filament, and he has nowhere drawn the line between it and a rod. The specification is, therefore, of itself argued bad as being too indefinite and vague. To this argument it may, in our opinion, be properly replied that in a patent of this description definition is required only to such an extent as would enable a practical workman to construct the required apparatus: that there is distinct evidence that such a workman could make the required apparatus from the specification: that no witness of the defendants alleges that such a workman would have any difficulty, or would require any further experiments, and that the specification itself, as we have already shown, contains descriptions of six forms of filament, and these descriptions, it is obvious, would afford material assistance to any workman in doubt." BOWEN and FRY, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January, 31, 1887). I., 312, **1247.**

It is objected that Edison's specification does not sufficiently show how the invention is to be carried into effect. It is necessary that this should be done so as to enable a person skilled in the art to make the thing without further invention. "But, in my opinion, it is not necessary that such a person should be able to do the work without any trial or experiment, which, when it is new or especially delicate, may frequently be necessary, however clear the description may be." That part of the specification which gives directions to make a combination of lamp-black and tar, out of which to make the filaments to be carbonized, is attacked as being insufficient. It was said that the secret was the necessity of kneading the material for a length of time, and with great pressure. Guimingham, for the trial of the previous action, made lamps with tar putty filaments, which were made exhibits in this action, and though there are no express directions in the specification how this putty is to be prepared, it is stated that it can be rolled into threads as small as 7-1000ths of an inch," and I think it would be obvious to any intelligent workman who wished to prepare the material that it must be kneaded so as to make it perfectly homogeneous, and to prevent any breaking of the thread in consequence of any particle of lamp-black not being perfectly amalgamated with the tar." COTTON, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 328-9, **1309-13.**

As to the objection that the specification of Edison's patent does not give sufficient direction as to the carbonization of a filament: "It is true that

PATENT IN SUIT—(*Continued*):

there was no trade in carbonizing anything so delicate as these filaments, but great care only in exercising a known process and applying it to an unusually delicate article, and no invention, would be necessary." COTTON, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 329-30, **1315-9.**

Defendants urge "that the coating with a non-carbonizable substance was injurious. The result of the evidence is that when the coating is a thin one the process can be, and is done without any injurious results." As to the objection that the specification does not direct the use of a thin coating, the evidence shows that a thin coating, by the so-called dusting process, would be naturally adopted. COTTON, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 330-1, **1320-1.**

"• • • I have come to the conclusion that what is meant by the expression 'carbon filament' can be gathered from the instances given in the specification, and that what is meant is any thread which can be and is bent into the required form, and can be and is carbonized when so bent. The thread, as shown by the examples, may be a fiber or a group of twisted fibers, or, as is to be gathered from the tar lampblack instance, it may be an artificial substance pressed or rolled into thread or wire like forms.

"• • • The sense in which the patentee has used the expression 'carbon filament' can, in my opinion, be gathered from the typical examples given in the specification and referred to in the judgment of Lord Justice FRY in the former case" (here follow extracts from the specification):

"The size of the filament is not stated; but it is quite clear, from the objects to be attained, that it must be long and thin, and nothing more definite is necessary to be stated. Having arrived at that conclusion, it follows that, in my opinion, the patentee has 'particularly described and ascertained the nature of the invention.'" LINDLEY, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 335-6, **1337-41.**

As to the contention by defendants, that carbon filaments could not be made as described in Edison's patent, "to insure success, all that is necessary is carefully to follow the instructions there given, bearing in mind the objects to be attained, and that the filaments are extremely delicate and easily destroyed.

This is, in my opinion, the fair result of the evidence: • • •." LINDLEY, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 338, **1351.**

As to whether Mr. Edison, in view of the early Swan lamp in evidence, added anything to what was known at the date of his patent, and sufficiently described the nature of what he added: "In my opinion he did; not,

PATENT IN SUIT—(*Continued*):

indeed, in words distinguishing his lamp from Swan's; but by giving and describing a new type of body to be rendered incandescent, or, if I may use such an expression, a new type of thread. One mode of trying this question is to ask whether any one would make such a thing as Swan's lamp 'F. J. B. 1,' if he took Edison's specification as his guide? I am convinced he would not; he would avoid and not reproduce Swan's carbon pencil, and would adopt Edison's type of carbon filament." LINDLEY, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 340, **1357.**

"The (Edison) patent appears to me to claim in distinct and unmistakable language every combination of any carbonized filament with any receiver of glass, through which leading wires pass, and from which the air is exhausted." BOWEN, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 341, **1363.**

As to whether the second claim of Edison's patent is too vague: "I see no reason to doubt that in the year 1879 the term filament, though new at that date as regards electric lighting, would nevertheless convey to the minds of ordinary persons of the class to whom this specification was addressed the idea of a slender thread or thread-like substance, and it seems to me that the specification indicates that the thread or filament was first to be formed and then to be subsequently carbonized. * * * The term filament is nowhere defined. It is a descriptive term, not a definition. But, it appears to me to indicate the nature of this particular factor in the combination in a way that describes and ascertains the nature of the invention so as to render it plainly intelligible to a skilled person of the class to whom the specification is addressed." BOWEN L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 341-2, **1364–7.**

"* * * the evidence shows that lamps made solely on the (Edison) patent will and do succeed, although subsequent improvements have been generally engrafted on the original design." BOWEN, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 343, **1370.**

I think "* * * that the specification (of Edison's patent) sufficiently describes and ascertains the nature of the invention, and that no reasonably competent operator, alive to the delicacy and care obviously requisite in forming and carbonizing so slight a thing as a filament, ought, without any exercise of invention but with reasonable watchfulness only and fair good-will, to have been embarrassed in making and carbonizing Mr. Edison's filaments. BOWEN, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 344, **1373.**

PULVERMACHER'S PATENT:

British Patent No. 4774 of 1878.

"* * * Mr. Pulvermacher's patent deals with two modes of lighting, the arc light and the incandescent, and it is very remarkable that having described in detail this spiral rod or thread for the purpose of his arc light, when he comes to state what his mode of procuring the incandescent lamp is, he discards his carbon conductor altogether and resorts to metallic wire. Whatever likeness there may be between Mr. Pulvermacher's spiral rod and Mr. Edison's coiled carbon filament, mentioned in claim 3, it is perfectly clear to my mind that Mr. Pulvermacher was wholly unware that the coiled thread of carbon could be applied for the purpose of incandescent lamps, because he certainly would not have discarded it when he came to make his incandescent lamp, which is provided for in the very same patent." BUTT, J. (High Court of Justice, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, May 20, 1886). I., 288, **1149-50.**

As to Pulvermacher's patent (November 23d, 1878, No. 4774): "This invention was intended for use in an arc lamp, and though referred to for other purposes, it was not urged upon us that it contained any anticipation of the combination contained in the second claim (of Edison)." BOWEN and FRY, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 310, **1240.**

Also see Commercial Success.

RESISTANCE:

See Stability.

ROBERTS'S LAMP:

"Now, comparing this apparatus with the second claim of Mr. Edison, we find that it differed in that Roberts did not use carbon as his sole material, that he was content with the exclusion of gases chemically destructive, and was not alive to the importance of the mechanically destructive action of gases, that his receiver was not made entirely of glass, and that the leading wires did not pass through glass, but through the metallic cap of the receiver." BOWEN and FRY, L. JJ. (Court of Appeal, in Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 308, **1232.**

Also see Commercial Success.

SHAPING:

"* * * the Attorney-General, although contending for a more general sense of carbon filament in the second claim, said that it is every filament, subject to this restriction or qualification—if he put any—that it must be made into a filament before it is carbonized. At first I thought that there was nothing in the specification which would lead to that conclusion, but on looking carefully at it, it appears to me highly probable

SHAPING—(*Continued*):

that the essential part of what he described in this specification as a filament was that it should be made into a filament—that is to say, into a fine wire or thread, or exist as a fine wire or thread before it was carbonized; and there are a great many passages in the specification, which is the only thing one would look to or rely on in the matter of construction, which will lead to that conclusion, because I find this on page 4. * * * There are other passages in the specification which show clearly that what was contemplated always was making a filament, and in these cases (the making of filaments from tar putty) rolling it before carbonization, * * *" COTTON, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 320-1, **1279-82.**

STABILITY:

"The problem before Mr. Edison was to find some conductor in which he could obtain high resistance to the current with great durability—that is to say, great capacity to resist disintegration by heat and the absence of all disintegrating influences of any gas, whether such influences were chemical or mechanical. The high resistance he might obtain from any use of the three factors already referred to—the specific resistance or length of the conductor or its sectional area. As we have already seen, Mr. Edison specified the conditions of this problem by using carbon, a substance of low conductivity (high specific resistance), in a form in which the length of the conductor was great in proportion to its sectional area, and by placing this conductor in a chamber not occupied by an inert gas, like nitrogen, but by a vacuum as complete as is obtainable." BOWEN and FRY, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 306, **1222-4.**

SWAN'S LAMP:

After referring to the occasions, prior to March 2, 1879, upon which Swan exhibited or described, in Great Britain, a lamp having a carbon rod or pencil hermetically sealed in vacuo in an all glass chamber, the opinion reads: "* * * from that time it has, so far as this case is concerned, disappeared from history, and this disappearance is, we think, cogent evidence that Swan's lamp as it was exhibited was not a practical success; that Swan could not do what Edison did, and that the difference between a carbon rod and a carbon filament was the difference between failure and success." BOWEN and FRY, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 311-12, **1243-5.**

The evidence "assists the conclusion at which the Court arrived, in the former action, that Swan's lamp of 1879 was not a success, and I think enables me to come to the conclusion that this lamp was an experiment which failed and was abandoned, and that the difference introduced by Edison was one which changed failure into success." COTTON, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 327, **1306.**

SWAN'S LAMP—(*Continued*):

The evidence shows that Swan's lamp, in evidence, was a failure, and that he had not got the key to success. His efforts to improve the lamp show that he was not thinking of filamentous carbons, but of other things. His lamp was an unsuccessful experiment. LINDLEY, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 339, **1354-5.**

As to the carbon burner in Swan's early lamp in evidence: "Was it a filament? The question is one of degree. I doubt whether it is one, and I still more doubt whether any one who saw it would understand it to be such. But, in any case, I think 'F. J. B. 1' never was more than an experiment, which was unintelligible on account of its failure and barren of all fruit, and which was regarded even by its inventor as practically valueless in the race." BOWEN, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 343, **1370-1.**

UTILITY:

When the case was tried in the Court below, "There was distinct evidence of the utility of the combination contained in the second claim (of Edison's patent) not, so far as was shown us, met by any opposing evidence. Indeed, the utility of the patent, and consequently of everything claimed by it, is not in dispute." BOWEN and FRY, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 305, **1218-9.**

The problem before Mr. Edison was to find some conductor in which he could obtain high resistance and great durability. He satisfied the conditions of this problem by using carbon, a substance of low conductivity, in a form in which the length of the conductor was great in proportion to its sectional area, and by placing it in a chamber having the best obtainable vacuum. "The importance of this combination can hardly be doubted, for, if not alone, yet in combination with other improvements it has had this result that, whereas, before November, 1879, two or three experimental lamps were all that had been produced; after that date such lamps have been produced by tens of thousands and constitute a most important element in our methods of lighting." BOWEN and FRY, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 306-7, **1223-4.**

As to the contention that no successful incandescent lamps were made in accordance with the Edison specification of November 10th, 1879, without the aid of subsequent improvements, "That, in my opinion, was a useful combination, and a patent is not to be defeated simply because subsequent inventions improved the patented article, or because in consequence of subsequent improvements no article was, in fact, made in accordance with the specification. But, in my opinion, it is established by the evidence that in fact incandescent lamps were made by Edison in accordance with the specification of 10th November, 1879,

UTILITY—(*Continued*):

and even sent by him to Dr. Hopkinson, and publicly run by him in March, 1880. I do not see any fact now brought before us which ought to induce the Court to depart, or would justify the Court in departing, from the previous decision of the Court on the question of the invention being useful and being the good subject matter for a patent." COTTON, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 326, **1302-3.**

" * * * On the evidence before us, many of these lamps were shown to have run for a sufficient time to prove that they could not be considered failures in this respect;" that is, the lamps with tar putty filaments are practically useful. COTTON, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 339, **1314.**

Lamps having the carbon filaments in combination with the other essentials mentioned in the second claim of Edison's patent are in constant use, and their utility is proved by the fact that this particular combination is used by everyone who makes incandescent lamps. "The utility of the patented invention, meaning thereby the above-mentioned combination, is incontestable." As to whether the second claim is too wide, considering what Mr. Edison invented, in that it gives him a monopoly of lamps having filamentary carbon burners, I think that the introduction of the carbon filament was a new departure of the highest importance in electric lighting; and if this be so, the claim is not too wide." LINDLEY, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 340-1, **1360-2.**

"It appears to me, moreover, to be proved, not only that every successful lamp since 1879 which is available for multiple arc lighting was employed as a filament, but also that there is no proof yet that any filament cannot be adapted to the patented combination. If this is so, why is the (second) claim too wide? It is not the fault, but the virtue, of the invention that it covers so large a field." BOWEN, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 342, **1368.**

" * * * The evidence shows that lamps made solely on the (Edison) patent will and do succeed, although subsequent improvements have been generally engrafted on the original design." BOWEN, L. J. (Court of Appeal, in suit of Edison and Swan Co. vs. Holland, February 18, 1889). I., 343, **1370.**

VACUUM:

See Stability.

VAN CHOATE'S PATENT:

" * * * A patent was granted to Mr. Van Choate (October 31st, 1878, No. 4388), in respect of which he deposited a provisional specification only. The material to be employed by this invention is vaguely described as 'composed or formed of asbestos, mica, platinum or carbon, as may be required to give the proper affinity and homogeneity to the material.' It is evident that this is no adequate description to enable any one without further experiment to ascertain of what the conductor is to be made, or of what form it is to be." BOWEN and FRY, L. JJ. (Court of Appeal, in suit of Edison and Swan Co. vs. Woodhouse and Rawson, January 31, 1887). I., 310, **1238.**

Also see Commercial Success.

EVERETT, Prof. J. D

GEISSLER TUBES:

The specific resistance of air is practically infinite ("Units and Physical Constants," 1886). VI., 4389.

FARADAY.

GEISSLER TUBES:

"Opposed to insulation is discharge." "That which is called simply *conduction* involves no chemical action and apparently no displacement of the particles concerned." "A third mode, namely, that by sparks or brushes, may, because of its violent displacement of the particles of the *dielectric* in its course, be called the disruptive discharge." "The next form of discharge has been distinguished by the adjective *disruptive*, as it in every case displaces more or less the particles amongst and across which it suddenly breaks" ("Experimental Researches in Electricity and Magnetism," 1838). VI., 4390.

FARMER, Prof. Moses G.

BURNER OF CARBON:

After alluding to his experiments, in 1858, with burners made of various metals, the writer states that "carbon, when inclosed in an atmosphere free from oxygen, also gave satisfactory results. Nitrogen, carbonic oxide and hydrogen are all suitable gases to surround the incandescent carbon. A vacuum is, perhaps, better, were it not for the difficulty in maintaining it" (Letter to Prescott, published in 1879). V., 3447.

LAMP, INCANDESCENT:

"A second method of producing electric light is by rendering a continuous bar of carbon incandescent in the air by the passage of a current of sufficient density to raise its temperature to a white heat. Here much of the light is due to the superficial oxidation of the carbon bar, and this may, perhaps, prove to be the most economical method of producing it. The third method is by inclosing the carbon bar in a closed transparent globe free from oxygen" (Letter to Prescott, published in 1879). V., 3449.

RESISTANCE, SPECIFIC:

"The resistance of carbon, unlike that of metals, does not vary greatly with the changes of temperature" (Letter to Prescott, published in 1879). V., 3449.

Note. This statement is now known to be incorrect, carbon when incandescent having about half the resistance that it has when cold.

SUBDIVISION:

"Since that time (1868) I have been almost continuously engaged in making further researches in this direction (the writer refers to subdivision); have studied the conditions under which incandescent bars of carbon can be used in sealed globes" * * * (Letter to Prescott, published in 1879). V., 3448.

Referring to the different ways of obtaining the electric light, the writer says: "The third method is by inclosing the carbon bar in a closed transparent globe free from oxygen. * * *

The fourth method is that of rendering some of the metals with high melting points incandescent by the passage of a current of great density.

FARMER, Prof. Moses G.

SUBDIVISION—(*Continued*):

This is the method to which I have given most attention and which promises to be the most convenient for minutely subdividing and widely distributing electric light. An entirely new field for electric engineers is thus opened, in which our accumulated stock of knowledge will be most usefully employed" (Letter to Prescott, published in 1879). V., 3449-50.

VACUUM:

After alluding to his experiments, in 1858, with burners made of various metals, and after stating that he obtained good results with carbon, the writer says that nitrogen, carbonic oxide and hydrogen are suitable gases to surround a carbon burner, but that "a vacuum is, perhaps, better, were it not for the difficulty of maintaining it" (Letter to Prescott, published in 1879). V., 3447.

FONTAINE, Hippolyte:

Note. Higgs's translation of Fontaine's works on "Electric Lighting" was published in 1878, but the corresponding French edition was issued in 1877. In the digest the earlier date is given, although the data may have been taken from Higgs's translation.

BURNER OF CARBON:

"There are numerous works on the construction of small electric foci, but to the present day none of the means devised have given practical results. It has been endeavored to use Geissler tubes and small incandescent carbons. * * *" ("Electric Lighting," 1st ed., 1877). VI., 4010.

The burners in the Konn lamp were made of "retort carbon" ("Electric Lighting," 1st ed., 1877). VI., 4015.

"The principal cause of the great expense that the use of light from incandescence entails, rests in the difficulty of preparing small carbons. * * *" ("Electric Lighting," 1st ed., 1877). VI., 4018.

In his tests upon subdivision with Konn lamps, the burners were made of retort carbon and were .0016 metre (.063 of an inch) in diameter, and the incandescent part was .018 metre (.7 of an inch) in length ("Electric Lighting," 1st ed., 1877). VI., 4020.

CANDLE-POWER:

The author states that the power of each Konn lamp, which M. Florent tried to use, has been valued at about 20 Carcel burners (about 190 candles) ("Electric Lighting," 1st ed., 1877). VI., 4018.

CARBON:

In speaking of the burners made of retort carbon which he used in Konn lamps, the author says: "Attentive examination of incandescent carbons through a strongly colored glass has shown that they are not uniformly brilliant. They present obscure spots, indicative of non-homogeneity, and the position of cracks which rapidly disintegrate the carbon ("Electric Lighting," 1st ed., 1877). VI., 4022.

After speaking of Davy's early experiments with the arc light, the author says: "In replacing the wood carbon by deposits collected from the walls of gas retorts, Foucault really opened up to the voltaic arc the epoch of useful applications. Retort carbon is, in fact, much more dense, and resists for a long time the destructive action of the voltaic focus." He states that retort carbon, however, is not uniform in density,

CARBON—(*Continued*):

sometimes splits, and works irregularly, producing variations in the brilliancy of the light, which are chiefly due to the presence of foreign matter ("Electric Lighting," 1st ed., 1877). IV., 2116-7.

"Several inventors have endeavored to substitute for carbons cut directly from the deposits on the walls of retorts, similar agglomerates, but purer; others have merely purified retort carbons. Some have obtained products very remarkable in respect to luminosity, but practically inapplicable on account of their extreme cost." Here follow descriptions of the processes of Staite, Edwards, Le Molt, Lacassagne and Thiers, Curmer, Jacquelain, Peyret, Archereau, Carré, and Gauduin ("Electric Lighting," 1st ed., 1887). IV., 2117-33.

Of Carré carbons, the author says they are more tenacious, harder, and better conductors of electricity than retort carbon ("Electric Lighting," 1st ed., 1877). IV., 2124.

In reference to Gauduin's process of making articles from a carbon agglomerate the author says: "The objects made in agglomerated carbon are, for one variety of carbon, as much more combustible as they are porous, and as much more porous as they are moulded with less pressure. The inventor himself used for his manufacture steel molds capable of resisting the highest pressure of a strong hydraulic press" (Electric Lighting," 1st ed., 1877). IV., 2127.

In regard to Gauduin's process of giving wood the definite form which the resulting carbon is to have, the author says that "then he converts it into hard carbon, and finally soaks it, as in the manufacture we have described" ("Electric Lighting," 1st ed., 1877). IV., 2133.

CARBONIZATION:

In carbonizing Carré's carbons, they are laid in a crucible upon a bed of coke dust, and the top layer is covered with coke-sand ("Electric Lighting," 1st ed., 1877). IV., 2123.

CROSS SECTION:

The carbon burners used by Fontaine, in his tests upon subdivision with the Konn lamps, were .0016 metre (.063 of an inch) in diameter, and the incandescent part was .018 metre (.7 of an inch) in length ("Electric Lighting," 1st ed., 1877). VI., 4020.

DURABILITY:

In regard to the Konn lamp, the author says: "Each carbon lasts about two hours, with the exception of the first, which is consumed nearly immediately * * *" ("Electric Lighting," 1st ed., 1877). VI., 4016.

DURABILITY—(*Continued*):

Concerning his own tests with Konn lamps, having retort-carbon burners, the author says that the first carbon lasts, on the average, twenty-one minutes, and that the succeeding carbons last for two hours, if the illuminating power is less than forty (carcel) burners (380 candles). At this power, however, the life of the burner is only half an hour, and only twenty-five minutes when burned at 65 (carcel) burners (617 candles) ("Electric Lighting," 1st ed., 1877). VI., 4021-2.

In his experiments with the Konn lamp, the author states that the best results as to candle-power, with a given battery, were obtained when Gauduin carbons, .0016 metre (.063 of an inch) in diameter, and .015 metre (.59 of an inch) long in their incandescent part, were used. The average light obtained was 5 (carcel) burners (47 candles), and the carbons lasted fifteen minutes on the average ("Electric Lighting," 1st ed., 1877). VI., 4023.

DYNAMOS:

In 1887 there were more than 200 Gramme dynamos in use ("Electric Lighting," 1st ed., 1877). VI., 4004.

"Personally, we have made, in two years, several hundred installations. * * * The invention of Mr. Gramme has brought about a large introduction of the electric light into factories and machine shops * * *" ("Electric Lighting," 2d ed., 1879). VI., 4153.

NOTE. The auther refers to the Gramme dynamo and to the arc light.

EVAPORATION:

"The vacuum never being perfect in the receivers, the first carbon is in greater part consumed. It would appear that consequently upon the little oxygen contained in the lamp being transformed into carbonic acid and carbonic oxide, the carbon should be preserved indefinitely. But there is then produced a kind of evaporation which continues to slowly destroy the incandescent rods. This evaporation is, besides, clearly proved by a pulverent deposit of sublimed carbon, that we have found on the interior surface of the bells, on the several interior parts: rods, contacts, hammers, &c." ("Electric Lighting," 1st ed., 1877). VI., 4022.

FILAMENT OF CARBON:

Under the head of Incandescent Lamps, the author says: "We have limited our inquiries to the lamps most valued, beginning, of course, with Mr. Edison; because we consider Mr. Edison, we cannot repeat it too often, as the true creator of incandescent lighting, and as one of the benefactors

FILAMENT OF CARBON—(*Continued*):

of mankind. • • • In England, Mr. Swan is considered to be the true inventor of the incandescent lamp. The fact is, that long before the Edison lamp had been heard of, he attempted the construction of a practical apparatus, and he had even shown, in a public meeting, lamps sealed with a blow-pipe and containing a small incandescent carbon. But it is certain that these lamps were not yet sufficiently perfected to be utilized industrially when the Edison fibrous filament lamp appeared. It is after the glorious success of this lamp that Mr. Swan renewed his labors and brought them to a useful end by following the road marked out by the American inventor" ("Electric Lighting," 3d ed., 1888). VI., 4345-6.

GEISSLER TUBES:

"It has been endeavored to use Geissler tubes. • • • The light obtained by the Geissler tube is so feeble that it can never be utilized practically, and numerous trials made in mines and powder mills have been without result" ("Electric Lighting, 1st ed., 1877). VI., 4011.

KING'S LAMP:

After referring to incandescent lighting and having said "• • • that at the present day it may be considered as within a purely scientific domain • • •," the author refers to King's patent as being the first document on the subject, and also to Petrie's iridium lamp. He then states that "several other patents have been taken out in America, France and England for the same kind of idea, but none of these appear more complete, more explicit and more practicable than King's: it is then useless to continue our nomenclature" ("Electric Lighting," 1st ed., 1877). VI., 4011 and 4013.

is much more favorable to large foci than to the divisibility of the electric light ("Electric Lighting," 1st ed., 1877). VI., 4023.

LAMP CHAMBER:

The Konn and the Bouliguine lamps, as described and illustrated, have a base joined to a glass chamber, the joint between which is made tight by rubber packing ("Electric Lighting," 1st ed., 1877. VI., 4015-9.

LAMP, INCANDESCENT:

"Lighting by incandescence has been studied for a long time, but its application generally presents so great difficulties that at the present day it may be considered as within a purely scientific domain, although a certain number of apparatus exist, working moderately well" (Electric Lighting," 1st ed., 1877). VI., 4011.

LAMP, INCANDESCENT—(*Continued*):

"Lighting by incandescence and the principle of its production had for a long time fallen into oblivion, when in 1873 a Russian physicist, M. Lodyguine, resuscitated both and invented a new lamp, which has since been perfected by Messrs. Konn and Bouliguine." After referring to Wild's account of this lamp the author says that "nothing is less practical nor less studied than the apparatus of this inventor. M. Kosloff, of St. Petersburg, who went to France in the hope of working the Lodyguine patent, perfected his lamp slightly without, however, bordering upon anything passable. In 1875 M. Konn, also from St. Petersburg, patented a more practicable lamp, represented in Fig. 46, which was constructed for the first time in Paris by M. Duboscq." Here follows a description of this lamp, which had a chamber closed at the bottom by a base with a packed rubber joint. It contained five "retort carbons" and was provided with apparatus whereby, when a carbon broke, a new one was automatically substituted for it to avoid extinction of the light. "Three of these lamps were introduced two years ago at the house of M. Florent, a merchant of St. Petersburg, and put in action with an 'Alliance' machine. Each carbon lasts about two hours, with the exception of the first, which is consumed almost immediately • • •." "The principal cause of the great expense that the use of the light from incandescence entails rests in the difficulty of preparing small carbons, which cost, as fitted, more than five francs per metre." In regard to the Bouliguine lamp, the author says that he has never obtained good results with it ("Electric Lighting," 1st ed., 1877). VI., 4013-20.

Speaking of Edison's platinum lamp, the author says: "The truth is that the celebrated inventor of the phonograph has only re-edited a platinum wire lamp, which has already been experimented with, perfected, and finally confessed to be unsuited to industrial use by several electricians of great merit" ("Electric Lighting," 2d ed., 1879). VI., 4158.

RESISTANCE, SPECIFIC:

The author gives the resistance of the retort carbon which he made into burners for use in his tests upon subdivision with Konn lamps ("Electric Lighting," 1st ed., 1877). VI., 4020.

NOTE. From the tabulated results given by Fontaine, Prof. Barker finds that the specific resistance of the carbon used by Fontaine was 572 microhms. V., 3423.

SHAPING:

In making burners from "retort carbon" to be used in his experiments upon subdivision with Konn lamps, the author says, "The first operation consisted in measuring the resistance of retort carbon of square section. • • • We subsequently rounded the carbons • • •" ("Electric Lighting," 1st ed., 1877). VI., 4020.

SUBDIVISION:

For lighthouse service, fortifications, maritime service, shores, armies and campaign, the electric arc light is superior to all others, and is equally suitable for show rooms and large work shops.

For trades carried on where there are numerous local subdivisions of the space, gas, oil and petroleum are preferable ("Electric Lighting," 1st ed., 1877). VI., 4003 and 4010.

"Three years ago much was said about a new system of electric lighting, the invention of a Russian professor, which consisted in causing the incandescense of a small rod of carbon. It was for some time believed that by the aid of this invention the light could be in some way indefinitely divided, and introduced everywhere for nearly nothing. Deeper study of this subject and numerous direct experiments have enabled us to reduce this system to its real value, which, if it be defective when we consider it as capable of causing a revolution in present lighting, is very remarkable, on the other hand, when we have in view only a small number of special applications. The Jablochkoff candles, about which also much was said, appear to us to merit the same appreciation. If they result in anything practicable, which is very possible, they will be useful in certain cases, but will be substitute for nothing absolutely" ("Electric Lighting," 1st ed., 1877). VI., 4006.

"There are numerous works on the construction of small electric foci, but to the present day none of the means devised have given practical results. It has been endeavored to use Geissler tubes and small incandescent carbons" ("Electric Lighting," 1st ed., 1877). VI., 4010.

Tabulated results of the candle-power obtained by Fontaine in his tests upon subdivision, made with Konn lamps arranged in series and also in multiple arc ("Electric Lighting," 1st ed., 1877). VI., 4021.

The King and Lodyguine lamps are much more favorable to large foci than to the divisibility of the electric light ("Electric Lighting," 1st ed., 1877). VI., 4023.

"The remarkable effects of the voltaic arc were no sooner foreseen than the idea arose of dividing the electric light, and even before the existence of a good regulator for a single light, King took out a patent for a lamp on the divided system." After alluding to the advance made in powerful arc lights, the author says: "On the other hand, the plan of dividing the light made no advance but remained still an object of experimental and speculative inquiry." After stating that it is difficult to decide whether the King or Jablochkoff light "approaches nearest to the true solution of the difficult problem of dividing the electric light," Fontaine says that

SUBDIVISION—(*Continued*):

"there exists at the present time no sufficiently practical system of so dividing the light as to render it generally available for the purposes for which gas is used" ("Electric Lighting, 1st ed., 1877). VI., 4027-8.

"By the term 'divisibility of the electric light' we do not mean the production of several intense lights by means of one machine or battery, but simply the maintaining of a few small luminous centres, each equal to 1 to 15 carcel (9.5 to 145 candles) burners. * * * At present, however, the means proposed for attaining this divisibility of the light have been practically without success. This opinion must be taken to refer entirely to the present time, and in no way to prejudge the future; * * *" After referring to the efforts of de Changy, Lacassagne and Thiers, de la Rive and Wartmann, Le Roux, Mersanne, Woodward, and finally to the experiments then being carried on by Jablochkoff, the author says: "* * * By this arrangement M. Jablochkoff hoped to produce fifty lights with a single magneto-electric machine. The aspirations of MM. King, Lodyguine, Konn, Kosloff and De Changy were of a like nature, and we wish M. Jablochkoff better success than his predecessors obtained" ("Electric Lighting," 1st Ed., 1877). VI., 4028-37.

"First of all, it can be affirmed that lighting by electricity has a field which is peculiar to it and where it does not even fear the competition of other systems. * * * For lighting private dwellings, gas offers the most desirable, the most convenient and the most economical means. Electricity will indeed be able here and there to penetrate into some large drawing-rooms or into some costly mansions, but this will be an exception so rare that it is not necessary to take account of it. * * * For lighting public ways gas also answers better. Still, the large avenues and open squares are already able to avail of the Jablochkoff candles. * * * For large shops, large cafés * * * the electric light in part is a means for lighting which will force itself upon them in all the important cities. For lighting factories, machine shops, forges, foundries and mines, the electric light presents itself, with its advantages and its inconveniences, in competition with gas, oil and petroleum." The author here cites the conveniences and inconveniences of electric light and gas light, and goes on to say of electric light that, "It loses much of its intensity when it is divided into small foci, which renders it difficult of application to small apartments. * * * If the workshops are made up of comparatively small rooms, if the ceilings are low, the machine tools large and crowded together, gas is generally preferable to electricity. If the rooms are large, the ceilings sufficiently high, the tools well apart, electricity is generally preferable to gas" ("Electric Lighting," 2d Ed., 1879). VI., 4154-7.

After describing the incandescent lamps of De Moleyns, Petrie, De Changy and Edison's platinum lamp, also those of King, Konn, Bouliguine and Fontaine, and the semi-incandescent lamps of Varley, Reynier and Werdermann, the author says: "Of all the physicists who

8

FONTAINE, Hippolyte.

SUBDIVISION—(*Continued*):

have occupied themselves with incandescence, M. De Changy has made the best spiral lamp, M. Konn the best lamp with carbons held in clamps or sockets, and M. Reynier the best semi-incandescent lamp. The last would, without doubt, arrive at a perfect solution of the problem of lighting by small electrical foci did it not present some difficulties almost insurmountable. In the actual state of affairs, with the electrical generators in use and the lamps proposed for utilizing the electricity, we do not believe that lighting generally by electricity can be made to succeed" ("Electric Lighting," 2d Ed., 1879). VI., 4159-60.

VACUUM:

In his tests upon subdivision with Konn lamps, the author exhausted the globe to 0.70 meter (about one-thirteenth of an atmosphere), mercurial pressure ("Electric Lighting," 1st Ed., 1877). VI., 4020.

GANOT.

GEISSLER TUBES:

At no degree of exhaustion is air a conductor ("Physics," 1890). VI., 4389.

GARDEN, Hugh R.:

was president of Electro-Dynamic Light Co.

DYNAMOS:

At a meeting of the Electro-Dynamic Light Company, September 10th, 1878, the president is authorized to order a dynamo machine, price $600 (McKeesport suit). V., 3280-1.

At a meeting of the Electro-Dynamic Light Company, February 25th, 1879, an agreement is entered into with Mr. H. L. Judd that he should go on at his own risk and expense to make a dynamo machine of the kind invented by Mr. W. E. Sawyer, Mr. Judd to receive one-quarter interest in the invention both in the United States and foreign countries (McKeesport suit). V., 3291-2.

ELECTRO-DYNAMIC LIGHT CO.:

Certificate of incorporation filed July 11th, 1878. July 15th, 1878, at meeting of company, resolved to acquire patents and patent rights belonging to Wm. E. Sawyer and Albon Man. The price paid to be, $300,000. President and secretary authorized to issue to Sawyer & Man the whole capital stock and two hundred and ninety thousand dollars in scrip certificates of the company, payable out of profits (McKeesport suit). V., 3271-2.

September 10th, 1878. President reports informal proposition to purchase $10,000 of company's scrip. President and treasurer are authorized to sell such scrip. President reports that he has expended and taken vouchers for $729.74 in the preparation of lamps and other electrical apparatus, and in payment to Sawyer of $250 for $1,000 worth of company's scrip. President authorized to make arrangements for placing the lighting apparatus in the Davol Mills, at Fall River, Mass. President authorized to order dynamo machine, price $600, and to employ Prof. F. N. Holbrook, of Columbia College, as chemist (McKeesport suit). V., 3280-1.

October 8th, 1878. President reports that he has made arrangements to equip the Davol Mills, of Fall River, at the expense of the mill company, with the apparatus of the Electro-Dynamic Light Company, the mill company to pay a royalty of one hundred dollars a year. President reports that the apparatus of the company is substantially complete for exhibition. That the present workshop is unsuitable for the exhibition

ELECTRO-DYNAMIC LIGHT CO.—*(Continued)*:

of the light and experimental purposes. President is authorized to procure suitable quarters for the company, and to pay Mr. Sawyer fifty dollars a week as electrician of the company. President is authorized to procure Letters Patent of the United States upon new inventions as speedily as he may deem it necessary (McKeesport suit). V., 3281-2.

October 15, 1878. President authorized to exhibit the light whenever he may deem it to the interests of the company. President authorized to procure letters patent in foreign countries, provided expense of procuring the same can be paid by sale of the stock of the company (McKeesport suit). V., 3282.

October 31st, 1878. Letter of Mr. Lowrey read, and a committee appointed to confer with Mr. Lowrey (McKeesport suit). V., 3284.

November 12th, 1878. Reading of two letters from Mr. Lowrey and Mr. Man's answer to the same. Treasurer reported as follows: Receipts from sale of stock and scrip, $2,616; money loaned by Mr. Man, $600; excess of salary paid E. L. Myers, $20. Total receipts, $3,236. Total expenditures to November 12th, $2,224.21. Balance in bank, $1,011.79. Scrip in treasury, $26,500. Treasurer reported that for the $600 borrowed of Mr. Man the vice-president and treasurer have signed a joint note. President authorized to pay the bill of Edw. P. Hampson for steam engine at company's workshop, amounting to $401.55, Mr. Hampson agreeing to replace the present engine by a larger one costing $1,065 (McKeesport suit). V., 3284-8.

December 12th, 1878. President reports that he has received from W. E. Sawyer an assignment to the company of seven applications for patents. Reports that he has not been able to sell stock of the company to pay for foreign patents, and therefore that the company has no interest in the foreign patents. Treasurer reports balance in bank of $737.79. Further reports that the company has borrowed $500 of Mr. Man on a demand note signed by the vice-president and treasurer; and that the company has borrowed of Jacob Hays $600, for which a demand note has been given by the president and treasurer. Mr. Lawrence Myers appointed superintendent of the company, with full power to supervise and direct the business of the company (McKeesport suit). V., 3288-90.

February 18th, 1879. The president and secretary are authorized to furnish lamps to applicants upon such terms as may be agreed upon between them and the applicants (McKeesport suit). V., 3290-1.

February 25th, 1879. Agreement with Mr. H. L. Judd that he should go on at his own risk and cost to make a dynamo machine of the kind invented by Mr. Sawyer, and that Mr. Judd is to receive one-quarter interest in

ELECTRO-DYNAMIC LIGHT CO.—*(Continued)*:

the invention both in the United States and foreign countries, and shall be employed to make the machines for the company. Treasurer authorized to borrow of all the trustees, excepting the secretary, the sum of $500, in proportion to their respective interests (McKeesport suit). V., 3290-2.

March 20th, 1879. Treasurer reports total liabilities at $3,536.72, of which there is due Albon Man, $1,850; Jacob Hays, $750; Hugh McCullough, $150; Lawrence Myers, $150; Wm. H. Hays, $150; J. P. Kernochan, $150; Man & Parsons, lawyers, $310.50. Balance in bank, $2.61. President reports that on Tuesday last he discharged the workmen at 94 Walker street, and gave them notice that nothing more would be required of them by the company. He consented that Mr. W. E. Sawyer might do work there. Mr. Meyers remains to look after the property of the company at a salary of $12 per week. "Mr. Sawyer has expressed to the president of the company the greatest possible confidence that the principle upon which he has been at work to build lamps is correct, and that those lamps that had been put up, except for some unknown reason (probably something about the filling), would be permanent and last forever. Some half a dozen or more lamps that are there are perfect and, he (Sawyer) believed, would never burn out, but remain as they are, but in his (Sawyer's) judgment a manufacture of lamps of that character was so uncertain that he declined to put them on exhibition anywhere. Since the last meeting of the company Mr. Sawyer has been at work principally upon a feeder lamp." The experiments made with this lamp showed that the carbon must be treated before it was put into the lamp. "Mr. Sawyer expresses confidence that lamps put up with a feeder of that kind will last forever, and he will be ready to put it on exhibition, but the president expresses his own views in regard to it that, while Mr. Sawyer's views are probably correct, personally, for other reasons, he is unwilling to go on expending money of himself and others in building lamps." Mr. Sawyer then proposed that, as the gentlemen present were unwilling to go on, he should be allowed the free use of the shop and tools of the company until the 20th of April, in and with which to conduct his own experiments at his own expense; that he be allowed three months' time in which to pay the debts of the company; that upon his paying the debts, not exceeding four thousand dollars in amount, all the members of the board present, except himself, shall turn into the company two-thirds of the stock and scrip originally held by them, to be used as working capital to raise funds for carrying on the business of the company, the same to be sold at no less than fifty cents on the dollar of par value. The proposition was considered and accepted. On motion, it was resolved that all authority heretofore given, expressly or by implication, to any officer of this corporation to contract debts for the company be and is hereby rescinded. That all expenses of the company, except the salary of Edwin L. Meyers, be revoked, and that he shall be continued in charge of the property of the company at 94 Walker street until otherwise ordered. That W. E. Sawyer be authorized to use, for ex-

ELECTRO-DYNAMIC LIGHT CO.—(*Continued*):

perimental purposes, at his own expenses, the office and premises, machinery and tools, of the company at 94 Walker street until the 20th of April next. The secretary agrees and assents that the feeder lamp is the property of the company (McKeesport suit). V., 3264-7.

April 8th, 1879. Secretary requested to state in the minutes that the feeder lamp made by him at the expense of the company for the United States is the property of the company, to which he agrees. Treasurer reports $2.61 as balnce in the bank. Total liabilities $3,666.69, of which amount there is due Albon Man, $1,862.50; Jacob Hays, $750; Hugh McCullough, $150; W. H. Hays, $150; Lawrence Meyers, $150; J. P. Kernochan, $150; Classon & Hays, $150 (McKeesport suit). V., 3292-3.

April 19th, 1879. The president was authorized to continue the use of the premises at 94 Walker street for a period of one month or longer, not to exceed three months from May 1st (McKeesport suit). V., 3293.

April 26th, 1879. President reports that the interferences Sawyer-Man-Keith and Sawyer-Man-Maxim are in a way of being arranged, the other parties admitting that there is no interference. President reports offer of $125 for the engine, and another from Mr. W. E. Sawyer, and advises that the engine, tools, &c., remain where they are for the present. The secretary is requested to note upon the minutes that the room at this meeting is illuminated by five feeder lamps manufactured by Mr. Sawyer and that all the trustees are well pleased with the exhibit. Resolved, that the bill of W. E. Sawyer for $51.80 for applying for patent on feeder lamp be approved and paid. Mr. Sawyer is directed to have model of feeder lamp made for the Patent Office as soon as possible. The secretary reports that the feeder lamp is complete, that nothing remains to be done but manufacture and sell lamps and switches; and, there being no necessity for further experimenting, he recommends that the workshop of the company be closed and the machinery and tools sold; that the dynamo machines be located in some place provided with power, and that an office be hired in which lamps may be charged and kept on exhibition, and the electricity be conveyed by wires from the dynamo machines to the office. The secretary states that it is impossible to make long carbons for the feeder lamps out of materials on hand, and that it is absolutely necessary to order a supply from France at once. Secretary recommended the immediate construction of twenty feeder lamps and switches at Mr. Judd's factory, or elsewhere. If the board desire to resume the position occupied by them previous to March 20th, 1879, the secretary makes the following propositions: 1st. Sawyer to be reimbursed for all moneys expended by him on his own account for the six weeks ending April 29th, amounting to $800. 2d. The company to pay him $3,500, for which he will assign $3,500 of his stock and scrip, which $3,500 shall be for his salary for the coming year. 3d. Sawyer to have the privilege of buying back the above $3,500 of stock and scrip within one year at par, and he will give his services to the company as electrician for the coming

ELECTRO-DYNAMIC LIGHT CO.—(*Continued*):

year without further consideration. 4th. A sale to be made of a sufficient amount of the scrip of the company to provide $2,500, to be used exclusively for the manufacture of lamps and expenses of exhibition. 5th. Sawyer, as electrician of the company, to have exclusive charge and direction for one year of the manufacture, charging and putting up lamps and all electrical work, subject only to the direction of the Board of Trustees. 6th. That an understanding be arrived at respecting the sale of rights, increasing the capital stock and admission to the company of certain capitalists with whom Sawyer has been negotiating to carry out his proposition of March 20th. Secretary's proposition entered in minutes and taken under consideration (McKeesport suit). V., 3294-7.

May 13th, 1879. President reports that Mr. W. E. Sawyer thinks he can make an arrangement with Mr. Thomas Wallace, of Ansonia, Conn., to go on and build and sell the lamps of the company, in lots of six or less, and to pay the company a royalty of three dollars per lamp. Resolved, that Mr. Albon Man be reimbursed for a dynamo electric machine purchased by him for the company. President reported that he had sold the company's steam engine for $165, and odds and ends of no further use to the company for $30.69, and that he has stored the rest in a store room over his office; that he has paid bills to the amount of $86.98, leaving in the hands of the treasurer $108.71. Resolved, that Mr. Joseph Tait be paid $200 for keeping the books of the company for one year from July 15th, 1878 (McKeesport suit). V., 3297-8.

May 14th, 1879. Mr. W. E. Sawyer gives formal notice that he shall not carry out the proposition made by him on the 20th of March, 1878, relative to a reorganization of the company, and that he withdraws such proposition (McKeesport suit). V., 3298.

May 20th, 1879. Letters of resignation of Messrs. Kernochan and Hays read, and resignations accepted. Mr. Thomas Wallace appointed trustee in the place of Mr. Kernochan. Mr. Wm. T. Hungerford elected trustee in the place of Mr. Hays. Mr. Man resigning the presidency, Mr. Wallace was elected to that office. It was resolved that the note of Mr. Wallace for $5,000 be used for paying off the debts of the company. Resolved, that Wallace & Sons be authorized to build and put up lamps and other apparatus of the company, paying to the company a royalty of three dollars per lamp for such lamps as they shall put up until some further and more positive arrangement can be made. Bill of H. L. Judd & Co. of $60, for work approved and ordered to be paid as soon as there are sufficient funds in the treasury. Mr. Meyer's resignation as trustee of the company presented and accepted. Mr. John B. Wallace appointed trustee in the place of Mr. Meyers (McKeesport suit). V., 3298-302.

June 10th, 1879. The attorney of Messrs. Wallace presented and read draft of a license between the company and Messrs. Wallace, and a committee,

ELECTRO-DYNAMIC LIGHT CO.—(*Continued*):

among others Mr. Man, was appointed to draw up such a license as the company is willing to give Messrs. Wallace for the right to manufacture and sell lamps under the company's patent, and the vice-president, Mr. Albon Man, was unanimously authorized to sign such license in behalf of the company (McKeesport suit). V., 3303.

SAWYER-MAN LAMP AND SAWYER'S FEEDER LAMP:

On March 20th, 1879, the president of the Electro-Dynamic Light Company reports that Mr. Sawyer expressed to him the utmost possible confidence that the principle upon which he has been at work to build lamps is correct, and that those lamps that had been put up, except for some unknown reason, would be permanent and last forever. But in his (Sawyer's) judgment a manufacture of lamps of that character was so uncertain that he declined to put them on exhibition anywhere. Since the last meeting Mr. Sawyer has been at work upon the feeder lamp, and expresses confidence that the feeder lamps will last forever. The president says that for personal reasons he is unwilling to spend any more money in building lamps (McKeesport suit). V. 3265.

April 26th, 1879, the secretary of the Electro-Dynamic Light Company is requested to enter on the minutes that the room at this meeting is illuminated by five feeder lamps manufactured by Mr. Sawyer, and that all the trustees are well pleased with the exhibit. The secretary reports that the feeder lamp is complete, that nothing remains to be done but manufacture and sell lamps and switches; also states that it is impossible to make long carbons for the feeder lamps out of materials on hand, and that it is absolutely necessary to order a supply from France at once. Recommends the immediate construction of twenty feeder lamps and switches at Mr. Judd's factory or elsewhere (McKeesport suit). V. 3295 6.

May 13th, 1879, Mr. Sawyer thinks he can make an arrangement with Mr. Thomas Wallace, of Ansonia, Conn., to go on and build the lamps of the company in lots of six or less, and pay the company a royalty of three dollars or less per lamp (McKeesport suit). V., 3297.

May 20th, 1879, the Electro-Dynamic Light Company passed a resolution that Wallace & Sons be authorized to build and put up lamps and other apparatus of the company, paying the company a royalty of three dollars per lamp for such lamps as they shall put up, until some further and more positive arrangement can be made (McKeesport suit). V., 3301-2.

SAWYER-MAN WORKSHOP:

At a meeting of the Electro-Dynamic Light Co., September 10th, 1878, the president reports that he has expended $729.74 in the preparation of

SAWYER-MAN WORKSHOP—(*Continued*):

lamps and other electrical apparatus. President is authorized to order dynamo machines, price, $600 (McKeesport suit) V., 3280-1.

At a meeting of the Electro-Dynamic Light Co., October 8th, 1878, the president reports that the apparatus of the company is substantially complete for exhibition, and that the present workshop is unsuitable for the exhibition of the light and experimental purposes. President is authorized to procure suitable quarters for the company (McKeesport suit). V., 3281-2.

Treasurer of Electro-Dynamic Light Company reports, November 12th, 1878, total expenditures to date $2,224.21. President authorized to pay Edward P. Hampson $401.55 for steam engine (McKeesport suit). V., 3288.

March 20th, 1879, the treasurer of the Electro-Dynamic Light Company reports total liabilities at $3,536.72. President reports that on last Tuesday he discharged the workmen at 94 Walker street and gave them notice that nothing more would be required of them by the company. He consented that Mr. W. E. Sawyer might do work there. Mr. Meyers remains to look after the shop and property of the company, at a salary of $12 a week (McKeesport suit). V., 3264

On March 20th, 1879, Mr. Sawyer asked of the Electro-Dynamic Light Co. the free use of their shop and tools until April 20th, to conduct his own experiments at his own expense. On this date it was resolved that all expenses of the company, except the salary of Mr. Edwin L. Meyers, be revoked, and that he be continued in charge of the company's property until otherwise ordered. Mr. Sawyer is granted the use of the shop and tools until the 20th of April (McKeesport suit). V., 3266.

April 19th, 1879, the president of the Electro-Dynamic Light Co. was authorized to continue the use of the premises at 94 Walker street for a period of one month or longer, not to exceed three months from May 1st (McKeesport suit). V., 3293.

April 26th, 1879, president of Electro-Dynamic Light Co. reports the offer of $125 for the engine, and another offer from Mr. Sawyer, and advises that the engine, tools, &c., remain where they are for the present. The secretary reports that the feeder lamp is complete and nothing remains to be done but manufacture and sell lamps and switches, and there being no necessity for further experimenting he recommends that the workshop of the company be closed and the machinery and tools sold. The secretary reports that it is impossible to make long carbons for the feeder lamps out of materials on hand, and that it is absolutely necessary to order a supply from France at once; also recommends the immediate

8

GARDEN, Hugh R.

SAWYER-MAN WORKSHOP—(*Continued*):

construction of twenty feeder lamps and switches at Mr. Judd's factory, or elsewhere (McKeesport suit). V., 3294-6.

May 13th, 1879, president reports that he has sold the company's steam engine for $165, and odds and ends of no further use to the company for $30.69, and that he has stored the rest in a storeroom over his office; that he has paid bills to the amount of $86.98, leaving in the hands of the treasurer $108.71. Mr. Tait is paid $200 for keeping the books of the company for one year from July 15th, 1878 (McKeesport suit). V., 3298.

May 20th, 1879, the bill of H. L. Judd & Co. of $60 for work, approved by the Electro-Dynamic Company, and ordered to be paid as soon as there shall be sufficient funds in the treasury (McKeesport suit). V., 3302.

GERMAN DECISIONS.

CLAIMS OF EDISON'S GERMAN PATENT:

"1. An electric lamp, which gives light by incandescence, and in the main consists of a filament of carbon of high resistance, which is made as described and secured to metallic wires.

2. A filament or strip of carbon fibers, wound into spiral shape in such a way that only a part of the surface of the carbon conductor radiates light.

3. The method herein described of securing the platina contact wires to the carbon filament, and carbonizing the whole in a closed chamber, as set forth" (Royal General Court of Justice, in Swan-Edison suit, March 9, 1885). I., 267, **1067.**

FILAMENT OF CARBON:

"The contested Patent No. 12,174 protects a certain kind of electric incandescent lamps, the chief peculiarity of which consists in the employment of a carbon fiber of high resistance for the purpose of giving light" (Imperial Patent Office, in Swan-Edison suit, January 24, 1884). I., 258, **1030.**

FIRST CLAIM OF PATENT IN SUIT:

"Regarding the method of production of the carbon fiber, reference is made in claim No. 1 (of the German patent) to the patent specification. In this is prescribed the carbonization of a cotton thread or the production of any other thin carbon wire made from fibrous material, or the carbonization of dough of lampblack and tar, rolled out to a thin wire, and in such a way that the material to be employed is to be given the spiral or other desired shape, which it is to retain after carbonization, and that thereupon carbonization is effected. From this two conclusions are drawn, viz., on the one hand, that by the term 'carbon fiber' used in the patent, not simply any carbon of vegetable origin is meant, but only the CARBON FILAMENT made and shaped in this peculiar way * * *" (Imperial Patent Office, in Swan-Edison suit). I., 258, **1030-1.**

"The circumstance that certain elements in the Edison lamp, not patented themselves, as, for instance, the use of vegetable carbon as the incandescing body, the spiral form of the same, etc., were known before the application for the patent, cannot bring into question the total construction of the lamp as protected by claim No. 1," of the German patent (Imperial Patent Office in Swan-Edison suit). I., 259, **1033.**

Claim No. 1 of the plaintiff's (German) patent "* * * covers, as an essential part of the patented invention, as a whole, the production of an

FIRST CLAIM OF PATENT IN SUIT—(*Continued*):

incandescing body of filamentary form for electric lamps by carbonization of cotton thread or other fibrous material (linen thread, wood splints, paper), or of a dough made from tar and lampblack (eventually graphite, carbon)" (Royal General Court of Justice of Berlin, in Edison-Naglo Bros. suit, March 8, 1885). I., 275, **1099.**

INFRINGEMENT:

"The Court has gained the conviction that by the manufacture of the Swan lamps claim No. 1 of the plaintiff's patent is being infringed, inasmuch as the same covers, as an essential part of the patented invention as a whole, the production of an incandescing body of filamentary form for electric lamps by carbonization of cotton thread or other fibrous material (linen thread, wood splints, paper), or of a dough made from tar and lampblack (eventually graphite, carbon). * * * *The lamps put on the market by defendants undoubtedly contain an incandescing body made by carbonizing a cotton thread to which by bending the desired shape has been given.* Therein an infringement of plaintiff's patent must be found. The method employed by Swan to parchmentize the cotton thread before carbonization may contain an improvement of Edison's process, but it does not justify the use of the latter without Edison's permission. The practical success of Swan's operation consists, according to the opinion of the Patent Office of April 5, 1884, in the fact that the texture of vegetable fiber is destroyed in the cotton thread. But this circumstance is not sufficient to establish a material difference between Swan's and Edison's incandescing body. How little weight the latter attributes to the vegetable fibrous texture of the carbon filament may be estimated when he admits a filament formed of tar and lampblack (where a fibrous texture is out of the question) as a choice side by side with the cotton thread. It is only essential that as an incandescing body a carbon of the peculiar filamentary form is used" (Royal General Court of Justice of Berlin, in Edison-Naglo Bros. suit, March 8, 1885). I., 275-6, **1098-103.**

NOVELTY:

"In none of the public prints referred to by plaintiff is a description of an incandescent lamp to be found which possesses the characteristic peculiarities of the Edison lamp as they are above set forth, especially the use of suitably made carbon thread for giving light by incandescence" (Imperial Patent Office, in Swan-Edison suit). I., 258-9, **1032-3.**

" * * * The carbon fiber, or, rather, the carbon filament, in spite of all the publications cited by the plaintiff, must be regarded as novel" (Imperial Patent Office, in Swan-Edison suit). I., 260, **1038.**

PATENT IN SUIT:

"The idea of invention protected therein (in the German patent) consists in the construction of an incandescing body, of filamentary form, of carbon

PATENT IN SUIT—(*Continued*):

manufactured by carbonizing cotton fiber, to which can be given the coiled shape by bending; consequently in the method of creating an incandescing body by working the otherwise brittle carbon into loops, spirals, &c., which body in its tenacity approaches the metals, but at the same time can resist the action of much higher temperatures and possesses such an electric resistance as to allow the division of the electric current" (Royal General Court of Justice of Berlin, in Edison-Naglo Bros. suit, March 8, 1885). I., 275, **1100.**

" * * * The substance of the present invention of Edison is based on the fact that in the first place a thread-like incandescing body of carbon substance is made, to which by bending could be given a coiled shape. This is borne out by the opinion of April 5th, and also by the affirmative answer to the first question in the opinion of December 30th. (Note: These refer to opinions of the Imperial Patent Office.) If afterwards the discovery is made that these carbon filaments can be bent even after carbonization, it cannot be assumed, because Edison unnecessarily prescribes that the bending should be done before carbonization, that a lamp provided with such a flexible carbon conductor could be made without the use of Edison's idea" (Royal General Court of Justice of Berlin, in Edison-Naglo Bros. suit, March 8, 1885). I., 277, **1106-7.**

SHAPING:

In the opinion of the Imperial Patent Office it is stated that a coincidence exists between the lamp of Edison's German patent and the Swan lamps, in so far as the latter contain a thread-like carbon conductor obtained by carbonization of a cotton thread, which was bent into the desired shape before carbonization. This is the essential part (Royal General Court of Justice of Berlin, in Edison-Naglo Bros. suit, March 8, 1885). I., 278, **1109.**

GORDON, J. E. H.

GEISSLER TUBES:

"When the discharge either of a coil or electrical machine is passed through a tube or other vessel connected to an air pump, it is found that, as the pressure diminishes, the length of spark which can be obtained increases. The length of spark given by a battery at ordinary atmospheric pressures in the following gases is the longest in the order in which they are enumerated: Hydrogen, nitrogen, air, oxygen, carbonic acid—it being nearly twice as long in hydrogen as in air. The spark does not appear to be dependent upon the specific gravity of the gas." As a result of experiments on the fall of electro-motive on a Geissler tube as compared with its fall on a wire, the author concludes that "this shows that the discharge is not a case of true conduction, but that, even at the lowest pressures, it is disruptive." His investigation "confirms Mr. De la Rue's discovery that disruptive discharges do not obey Ohm's law." Spottiswoode says that, "these (discharge) currents are alternate not only in direction, but also in time, and no one of them is produced until after the complete extinction of its predecessor." De la Rue and Müller say that the discharge in the vacuum tube "cannot be considered as a current in the ordinary acceptation of the term, but must be of the nature of a disruptive discharge, the molecules of the gas acting as carriers of electricity" ("Electricity and Magnetism," 1880). VI., 4392-4.

HAYES, CHAS. H.:

is an electrician. Has been in the employ of Wallace & Sons since 1866 or 1867; knew Mr. Sawyer when he was working on incandescent lights at Wallace's.

CROSS-SECTION:

The carbon marked "Hayes' Carbon No. 1," has a diameter of 31¼ thousandths of an inch, and was the size of carbon that I saw Mr. Sawyer use at Ansonia. II., 1181, **4721-2.**

The carbons I saw used by Mr. Sawyer in his lamps at Ansonia were not much over one thirty-second of an inch in diameter. Admits that a fragment of the burner in the lamp exhibit ("Hayes Carbon No. 2") is nearly twice that diameter. II., 1185, **4738.**

HYDRO-CARBON TREATMENT:

The carbon marked "Hayes Carbon No. 1" has a grayish or silvery appearance, caused by the process of treatment by an electric current applied to the carbon when it was immersed in oil or something of that sort. I many times saw Mr. Sawyer treating carbons in this way at Ansonia. II., 1180-1, **4720-1.**

SAWYER'S LAMP:

Of the first five lamps I saw Mr. Sawyer use, only one, I think, was a feeder lamp; the other four either had no feeding apparatus, or the feeding apparatus was defective and would not work. In the feeder lamps the feeding mechanism operated to move the carbon pencils upward through the carbon jaws, so as to make a contact with the carbon rollers above it. The wearing away of these carbon rollers was due to an imperfect contact with the carbon pencil, thereby forming a little arc and burning. II., 1183-6, **4731** and **4742-4.**

HAYS, Jacob:

is retired from business and now engaged in the management of railroads and steamboats. Was a director and treasurer of the Electro-Dynamic Light Co. in 1878 and 1879.

BURNER OF CARBON:

I have seen Sawyer-Man lamps having curved carbons of a horse-shoe shape, from half an inch to an inch in length. II., 1172. **4685.**

CROSS-SECTION:

Some time between October, 1878, and February, 1879, I ordered some Carré carbons from Paris, France. They were from 2 to 4 inches long and about the thickness of an ordinary inch brass pin. I saw carbons used in the lamps at 94 Walker Street that appeared to be about that size. II., 1168-9. **4671-6.**

DURABILITY:

The longest time that I ever saw any of the Sawyer-Man lamps burning was two to three hours. II., 1170. **4679.**

HEBARD, Geo. W.

President United States Electric Lighting Co. Has been connected with that company since 1881.

CENTRAL STATION LIGHTING:

The only central stations that the United States Company ever tried to establish with defendants' M lamp, which is of 16 candle-power and has a hot resistance of about 40 ohms, were the one at 120 Broadway and another at the corner of Sixth avenue and Twenty-fifth street. In November, 1880, the United States Company ran a circuit from 120 Broadway and vicinity, adding lights from time to time until they had 231 lights, distributed among seventeen different customers. The company found it impossible to do a remunerative commercial business with this lamp, for the reason that, although they provided a large cable, the loss of current upon the line was so great as to cause great variation in the electromotive force of the current, and a large breakage of the lamps in consequence thereof. The cost was much in excess of the price of gas, customers being charged 1¼ cents per hour per lamp, and extra for lamps and renewals. After something more than a year; the experiment was abandoned. From the station at the corner of Sixth avenue and Twenty-fifth streets, circuits of heavy wire were run over to Madison Square and lights were added until there were 133 supplied to seven different customers. The experience here was the same as at the down-town station, and it was abandoned after about a year. III., 1967.

The United States Company have never used lamps, like complainants' exhibit "Defendants' Zigzag Paper Lamp," in multiple arc to any considerable extent in central station lighting. In a few instances machines to supply customers near by have been made for 250 lights or less. III., 1969.

COMMERCIAL SUCCESS:

For the year ending March 31st, 1882, the sales of lamps by the United States Electric Lighting Company amounted to $36,437. III., 1964.

In November, 1881, the volume of business done by the United States Company in arc lighting probably exceeded the volume of that done in incandescent lighting, but about the time that I became president of the company, or shortly before that, the incandescent business had increased largely, and we were behindhand in our orders for some months. III., 1973.

INFRINGEMENT:

I have never heard that our company was notified, prior to the bringing of the bill in this suit, that it was infringing the Edison Patent No. 223,898. A circular-letter was received from the Edison Company about the middle of June, 1882, and another dated November 9th, 1882, reciting lists of patents, and signed by the secretary of the Edison Company. So far as I know these are the only notices ever received by the United States Company from the Edison Company. III., 1965.

This suit is one of thirty instituted in May, 1885, against the United States Electric Lighting Company and its licensees. These were the first suits brought by the Edison Company against the United States Lighting Company. There are involved in these suits fifteen patents, all of which, with one exception, were granted to Thomas A. Edison. III., 1966.

The use of the M lamp in 1880 and 1881, by the United States Company was known to the Edison Company, for we were in frequent and repeated competition for business during 1881 and afterwards, and our installation at No. 120 Broadway, attracted many visitors. III., 1968.

Through the public press and by advertisements, etc., the officers of the United States Company were aware that the Edison Company claimed to own patents covering everything relating to electric lighting by incandescence, and that the lamps made by the United States Company were covered by patents owned by the Edison Company. V., 1971.

A large number of parties have come to the United States Company, prior to the commencement of the present suit, trying to make some arrangement for stopping competition and unnecessary patent and legal expenses, apparently thinking they might make money as brokers, and individual stockholders of the United States Company have had conversations looking to the same effect with stockholders of the Edison Company, but the conversations were on the broad subject as above stated, and did not refer specifically to the patent in suit nor to any other patent or group of patents. III., 1978-9.

ISOLATED LIGHTING:

The M lamp has been largely used in isolated lighting. The largest machine we ever made for use with these lamps was capable of supplying current for one hundred M lamps. By coupling two machines together double the number of lamps could be supplied in the same circuit. III., 1968.

The zigzag 70-volt paper lamps were used prior to May, 1885, for isolated lighting, usually in multiple arc, and in central station lighting in multiple series. The largest plant installed by our company with these 70-volt lamps had 1,000 or 1,200 lamps, arranged in multiple arc. The largest plant ever installed by our company had 4,600, 16 candle-power lamps of

ISOLATED LIGHTING—(*Continued*):

110 volts. This plant was at 120 Broadway. The present plant was installed in the summer of 1888. In the first plant in this building there were 700 or 800 70-volt lamps. After the experimental plant installed in 1880 was discontinued, we sold the Equitable Life Assurance Company 200 or 300 of the 40-ohm M lamps, which were afterwards replaced by the larger plant of 70-volt lamps. III., 1976.

Since testifying that the largest number of zigzag lamps installed by our company was from 1,000 to 1,200 lamps, I have learned that the New York Post-office plant consists of seven or eight 250-light machines. But there, as in other plants referred to, the lights are massed near the machines. The M lamp was largely used in small plants of 50 or 100 lamps, as, *e. g.*, on ferry-boats and in small factories, where the lights are not widely distributed. III., 1977.

LAMPS INCANDESCENT:

The lamp made and sold by our company between March, 1881, and April, 1882, had an M-shaped carbon, of about 40 ohms resistance hot, and of sixteen candle-power, and was substantially the same as Complainant's Exhibit Defendant's M-shaped Lamp in evidence. III., 1966.

The zigzag paper 70-volt lamps were first made during the spring or early summer of 1883, and they were used both in multiple arc and multiple series lighting. III., 1974.

MULTIPLE ARC:

In small isolated plants, and in the experimental stations at 120 Broadway, and on Sixth avenue, the M lamps were used in multiple arc, and in some small isolated plants they are so used to-day. There were several isolated plants using two one-hundred light machines each, and it may be possible that one or two plants were installed with three one-hundred light machines. III., 1973.

PATENT IN SUIT:

Prior to the bringing of the bill in this suit, our company was never, to my knowledge, notified that it was infringing the Edison Patent No. 223,898. Our company did receive, in 1882, two notices reciting lists of patents signed by the secretary of the Edison Company. III., 1965.

Prior to the beginning of this suit I was not aware, and, so far as I know, none of the other officers of the U. S. Company were aware, that the Edison Company claimed that the lamps of the United States Company were an infringement of the patent in suit. III., 1976.

HIGGS, PAGET.

SUBDIVISION:

"It may be laid down as proved by experience that for lighting large spaces, not too much subdivided, the advantage is greatly in favor of the electric light, but that where numerous light centres of small intensity are required, or where the space is much subdivided, the advantage is in favor of gas. This advantage will cease when a practical method of subdividing the electric light has been obtained" (Paper on "Some Recent Improvements in Dynamo-Electric Apparatus," January 22, 1878). VI., 4038.

"'The Division of the Electric Light' is a term, the true rendering of which should be the 'Division of the Electric Current,' to produce small light centres instead of one or more powerful lights. Some inventors have claimed the power to 'indefinitely divide' the electric current, not knowing or forgetting that such a statement is incompatible with the well-proven laws of conversion of energy. Whether the electric current be utilized in the production of light, either by means of the voltaic arc or of incandescence, the production of a certain amount of light depends upon the amount of current passing, not directly, but in such a proportion that offers speedy limit to the number of lights to be obtained." After illustrating the effect of dividing the current by an example, the author says that "with a given current-source the division of the electric current is, therefore, anything but 'indefinite.'" Finally Higgs concludes, contrary to what is now the practice, that the series method of arranging lamps offers advantages towards subdivision over a multiple arc arrangement, because "The reason for this is almost obvious, for whereas the reduction in lighting power in multiple arc is greater than in relation to the square of the number of lights, in the case of a series of lamps on a single circuit, the reduction results from the loss of current due only to the increased resistance, a matter merely of direct proportion" ("The Electric Light in its Practical Application," 1879). VI., 4097-100.

HOPKINSON, Dr. John:

states, in 1879, that he is a Fellow of the Royal Society and a Doctor of Science of the University of London; is a civil engineer and has, for past seven years (since 1872) been engaged in construction of lighthouses, and consequently taken great interest in the subject of electric lighting. VI., 4116.

LAMP, INCANDESCENT:

"The real loss in these incandescent lamps lies in this, that the temperature cannot be driven to so high a point as when the electric arc is used; but not even iridium, which has perhaps the highest fusing point of any metal, will stand the temperature of the electric arc without melting or being volatilized" (Testimony before the Parliamentary Committee on Lighting by Electricity, May 9, 1879). VI., 4116-7.

SUBDIVISION:

Practically there is a loss of economy in dividing the current into several electric lights, because in the divided lights we have much smaller lights, and therefore a lower temperature and a less proportion of radiation sensible to the eye (Testimony before the Parliamentary Committee on Lighting by Electricity, May 9, 1879). VI., 4116-7.

HOWELL, John W.

states that he is the electrician of the Edison Lamp Company.

CANDLE POWER:

The tar-putty lamps, made by me in accordance with the specification of the patent in suit, were tested as to candle-power during 600 hours burning, and made a remarkably good showing, the candle-power at the end of 600 hours being 85% of its original power. V., 3465-6.

CARBONIZATION:

Contrary to what Prof. ElihuThomson thinks, I have found that there was no necessity to employ a shrinkable mandrel to prevent rupture and displacement of the tar-putty filaments during carbonization. V., 3469.

CLAMPING:

I attached the tar-putty filaments to the pieces of platinum by means of the tar-putty mixture of which the filaments were made. V., 3461.

In all my tar-putty lamps the burners were joined to the platinum wires by the use of the tar-putty cement, and before carbonization. A small piece of the tar-putty cement was pressed by the fingers around the platinum wire and the end of the filament. V., 3490.

COMMERCIAL SUCCESS:

The lamps in evidence made with the tar-putty filament, in a test extending over 600 hours, proved to be practical and commercial lamps. V., 3465.

CROSS SECTION:

The burner of the Patent Office model of the lamp of the patent in suit is 15 thousandths of an inch in diameter and 4½ inches long. V., 3473.

Other things being equal, the conductivity in round conductors varies as the square of the diameter, and the resistance varies inversely as the square of the diameter. V., 3480.

My experiments show absolutely no distortion of the carbon tar-putty filament during heating and exhaustion, hence no change in the dimensions of the filament could have taken place. V., 3486.

DURABILITY:

The lamps in evidence having the tar-putty carbon filament were tested for 600 hours to determine their durability. The results showed that tar-putty is a very good material for making carbon filaments. Out of six lamps only one failed, and that was on account of a poor vacuum. V., 3465-6.

My experiments prove that the spiral form into which the tar-putty filament is wound does not produce unequal heating to such a degree as to impair to any great extent the durability of a lamp thus made. V., 3470.

EFFICIENCY:

The tar-putty lamps, in the test of 600 hours, proved to be of higher efficiency than the first bamboo-carbon lamps made and sold by the Edison Company. They were thus proved to be commercially efficient lamps at the date of the patent in suit. V., 3466.

FILAMENT OF CARBON:

The carbon filaments of incandescent lamps are practically stable under the conditions in which they are ordinarily used. They keep their shape and size unimpaired after burning 1,000 hours, and when they break it is not on account of wearing away. V., 3475.

If incandescent lamps were made without electrically heating the carbon filaments during exhaustion, the current used in operating the lamps would effect a reduction in the resistance of the carbon burners, depending in amount upon the temperature of carbonization employed in carbonizing the filaments in the furnace. The filament would be reduced in resistance in this way nearly as much as by the high heating during exhaustion used by the Edison Company. V., 3491.

FILAMENT OF TAR-PUTTY:

During the months of March and April, 1890, I made a number of lamps having filamentary carbon burners of the tar and lamp black composition, secured to platinum wires or tips before carbonization, arranged in the form of a spiral. The lamps were made strictly in accordance with the specifications and drawing of the patent in suit. V., 3460.

The process of manufacture of the tar-putty lamps pursued by me was as follows: The lamp-black used was made at our factory, the coal tar being obtained at the gas works at Newark and used just as it came from the gas works. The lamp-black, having been calcined as described in the patent in suit, was mixed with coal tar, the two being then thoroughly kneaded, until the whole was of the consistency of thick putty. The compound was rolled upon a piece of glass until it was from six to seventeen-thousandths of an inch thick in different pieces, then cut into pieces five inches long, and attached by the ends to small pieces of platinum by

FILAMENT OF TAR-PUTTY—(*Continued*):

means of the same tar and lamp-black mixture. The pieces with the platinum attached were coiled into spirals, which were then packed in powdered plumbago and carbonized, some of the spirals being dried in an oven at a temperature of 200°, before they were placed in plumbago and carbonized. Lamps numbered 1-18 were made in this manner. Lamps Nos. 19-26 were treated in the same way, but were wound into spirals between the coils of a copper wire helix, then dried and carbonized as before, the copper wire being afterwards eaten away by nitric acid. All these carbons were then mounted upon glass holders, glass globes were blown over the whole with a leading tube for exhaustion by the mercury pump, and the lamps were then exhausted. Lamps 27-31 were made and treated like the others and were bent into the form of a loop or hair pin, then dried and carbonized. V., 3461-2.

The furnace used by me in carbonizing the filaments of tar-putty, the method of carbonization and the tools employed were such as were known and would have been used by a skilled workman at the date of the patent in suit, while following out the directions given in the specification. V., 3463-4.

The tar-putty filaments, which I made after being enclosed in the lamps, were subjected to tests to determine the durability, candle-power and commercial value as lamps. The result of the tests was a remarkably good showing and demonstrated that, both as to durability and candle-power, tar-putty is a very good material for making carbon filaments. V., 3465-6.

Contrary to the opinion expressed by Prof. Elihu Thomson, the defendant's witness, I found no difficulty whatever in rolling tar-putty and producing a thin uniform thread, as described in the patent in suit. The thinner these filaments are made by rolling the harder and denser they get, and it is easier to manipulate a thin tar-putty filament than it is a thick one. I cannot imagine a much easier process than coiling one of these tar-putty filaments upon a mandrel. My experience showed that there was no difficulty in winding the tar-putty filaments between the coils of the copper helix. These tar-putty filaments soften very little, if any, when heated. Contrary to what Prof. Thomson has said would take place, I found no difficulty whatever on my first trial in attaching the platinum wires to the tar-putty filament before carbonization and successfully carbonizing the filament, thus making a perfectly good joint between the platinum and carbon. The thin tar-putty filaments when first heated immediately become hard and rigid, capable of supporting the platinum wires, and no method of supporting them independently of the coil is necessary. V., 3466-9.

In practice tar-putty filaments show no tendency to rupture or displacement of parts during carbonization. V., 3470.

FILAMENT OF TAR-PUTTY—(*Continued*):

My experience shows that the spiral form into which the tar-putty filament is wound does not impair the durability of the lamp to any great extent. V., 3470.

Prof. Thomson gives the following reasons why, in his opinion, a lamp like that shown in the drawing and made by processes known prior to the date of patent in suit could not be used commercially: (1) Lack of uniformity in the temperature and incandescence of all lamps of the system; (2) lack of uniformity in color of light emitted from all the lamps; (3) lack of uniformity of radiating surface for lamps of the same candle-power; (4) lowering of the vacuum; (5) the fatal defect of attaching the wires to the burners before carbonization, thus setting the conditions of the lamp and preventing variability or adjustment. Difficulties 1, 2 and 3 exist in all lamps, even in the best made to-day. They are to-day avoided by selection of the lamps to be burned on one circuit and the same method would overcome these difficulties with tar-putty lamps. The tar-putty lamps show remarkable uniformity, more so than some lamps at present made and used with very great success. Difficulty 4 is overcome by electrical heating during exhaustion of the lamp. Although the 5th difficulty was present in all the lamps made by the Edison Company during the first six or seven years of its existence, in the same degree as in these tar-putty lamps, and certainly did not interfere with the lamps being practically and commercially successful. V., 3472.

A carbonized cotton thread having a resistance of 2,000 ohms and a radiating surface of three-sixteenths of an inch, which is referred to in patent in suit, would not have to be closely coiled, and need not be coiled at all. The drawing of patent in suit shows an open spiral and a filament only about three inches long. V., 3473.

The burner of the Patent Office model of the patent in suit is fifteen-thousandths of an inch in diameter and 4½ inches long, and, if made of tar-putty, would have a resistance cold of 86 ohms. If a burner were made of the tar-putty of the same dimensions as the straight filament shown in drawing in patent in suit, its resistance would be 25 ohms cold. V., 3473-4.

Howell's Tar-Putty Lamps Nos. 23 and 26 have nearly the same dimensions as the Patent Office model of the patent in suit. V., 3474.

In making the tar-putty filaments, coal tar is to be used and not wood tar. This is indicated in the patent in suit by the directions to moisten the lamp black and knead it until it has the consistency of putty, which could not be done with wood tar, as the latter is solid. V., 3477.

The density of the tar-putty filaments becomes little, if any, greater on being rolled into shape. V., 3478.

FILAMENT OF TAR-PUTTY—(*Continued*):

At the time of my experiments with the tar-putty filaments I was not aware of the nature of the experiments made on tar-putty filaments involved in certain suits on the Edison English patents. V., 3481.

The specific resistance of the tar-putty filaments made by me is 8,617 microhms. V., 3484.

The resistance of the tar-putty filaments is changed by electrical heating during exhaustion. Their resistance after exhaustion is only one-twentieth to one-fortieth of what it was before exhaustion. V., 3486.

I found that there was absolutely no distortion in the tar-putty filaments during heating and exhaustion, hence I infer there was no change in dimensions. V., 3486.

The radiating surface of tar-putty filaments of Howell's lamps Nos. 19, 20 and 21 is about 0.286 square inch. The resistance after carbonization, assuming a length of 13 inches, is about 1,200 ohms. V., 3488.

I joined the tar-putty filaments to the platinum wires by means of tar-putty cement applied by the fingers. V., 3490.

GASES:

There are gases in the tar-putty connections between the filaments and the platinum wires. But the electrical heating during the exhaustion of the lamps, removes the gas from the connections and entirely obviates the difficulty mentioned by Prof. Elihu Thomson. The vacuum in the tar-putty lamps showed no depreciation at the end of the 600 hours' test. V., 3471.

HEATING DURING EXHAUSTION:

Electrical heating during exhaustion of the lamps, removes the gases in the connections between the carbon of filaments and the platinum wires, and obviates the difficulty mentioned by Prof. Elihu Thomson, of obtaining a good vacuum. V., 3471.

Electrical heating to drive off the gases from the carbon was well known at the date of the patent in suit. V., 3482.

Electrical heating during exhaustion changes the resistance of the tar-putty burners more than of the bamboo burners, because the latter are heated to a higher temperature during carbonization. V., 3484.

The resistance of a tar-putty carbon filament, if used in a lamp made without heating during exhaustion, would, I believe, be reduced to a much lower point than would the resistance of such a filament by high heating during exhaustion. V., 3493.

LENGTH:

The length of the burner of the Patent Office model of the patent in suit is 4½ inches, its diameter fifteen thousandths of an inch, and assuming it were made of tar-putty, its resistance cold would be 86 ohms. V., 3473-4.

PATENT IN SUIT:

During the months of March and April, 1890, I made a number of lamps from the tar and lamp-black composition described in the patent in suit. These lamps had filamentary carbon burners secured to platinum wires or tips before carbonization, had a spiral form, and were made strictly in accordance with the specification and drawing of the patent in suit. V., 3460.

The patent in suit indicates a restriction of the radiating surface by coiling, but I see nothing in the patent to indicate what degree of restriction was intended. The dimensions given in the patent are for the purpose of showing the possibilities of working the tar-putty, and not as indicating the size of the filament to be used. Drawing of the patent shows an open spiral and a straight filament only about three inches long. V., 3473.

The patent in suit clearly indicates the use of coal tar rather than wood tar in making the tar-putty mixture, by saying that the lampblack is to be moistened and kneaded until it assumes the consistency of thick putty. Wood tar being solid, could not be used, while coal tar answers admirably. V., 3477.

Patent in suit does not indicate that all the figures of the drawing are made to a definite scale. V., 3490.

RADIATING SURFACE:

The tar-putty filament lamps made by me showed a remarkable uniformity in radiating surface, more so than some successful lamps of the present day. V., 3472.

Patent in suit indicates a restriction of the radiating surface by coiling, but the degree of restriction is not indicated. Carbonized thread burners having a resistance of 2,000 ohms and a radiating surface of $\frac{3}{12}$ of an inch, which is referred to in patent in suit, would not have to be closely coiled and need not be coiled at all. V., 3473.

The radiating surface of tar-putty filaments of Howell's lamps Nos. 19, 20 and 21 is about 0.286 of a square inch. V., 3488.

RESISTANCE:

If the burner of the Patent Office model of the patent in suit were made of tar-putty its resistance would be 86 ohms cold. V., 3474.

RESISTANCE—(*Continued*):

The resistance of the tar-putty filaments made by me after heating during exhaustion was only one-twentieth to one-fortieth of what it was before exhaustion. V., 3486.

The resistance of tar-putty filaments of Howell's lamps Nos. 19, 20 and 21, assuming the length to be 13 inches, is about 1,200 ohms after carbonization. V., 3488.

If incandescent lamps were made without heating the carbon filaments during exhaustion, there would be almost as much reduction in resistance by the current used in lighting them, as is brought about by the high heating during exhaustion, as practiced by the Edison Company. V., 3491.

In all cases the reduction in resistance is caused by heating the carbon to a very high temperature, and I do not think the effect would be any less if the lamp were not upon a vacuum pump than if it were upon such pump. From results obtained in some of my experiments I believe that the resistance of a tar-putty carbon burned in a lamp made without heating during exhaustion would be reduced to a much lower point than would the resistance of such carbon by high heating during exhaustion. V., 3492-3.

The tar-putty lamps showed a gradual diminution in resistance during the entire 600 hours in which they were tested. Other things being equal, the illuminating power would increase as the resistance diminished. V., 3494.

RESISTANCE, SPECIFIC:

The specific resistance of the tar-putty filaments is 8,617 microhms. V., 3484.

The specific resistance of the tar-putty filaments is changed, as in other burners, by electrical heating during exhaustion. V., 3485.

The resistance of the tar-putty filaments made by me after heating during exhaustion was only one-twentieth to one-fortieth of what it was before exhaustion. V., 3486.

The specific resistance of the bamboo carbon lamps made at present by the Edison Company is, 5,788 microhms. V., 3491.

SHAPING:

Contrary to the opinion of Prof. Elihu Thomson, I have found that there is no difficulty whatever in rolling tar-putty into a thin uniform thread and in coiling the tar-putty filament, made according to the specification of the patent in suit, into a spiral. V., 3467.

HOWELL, John W.

SHAPING—(*Continued*):

I found no difficulty in obtaining spirals of tar-putty with evenly spaced coils, by winding upon the copper helix. With such a helix it would be difficult to get coils that were not evenly spaced. V., 3470.

The patent in suit indicates a restriction of the radiating surface by coiling, but the degree of restriction is not clearly indicated. A carbonized cotton thread having 2,000 ohms resistance, and a radiating surface of three-sixteenths of an inch, would not need to be closely coiled or even coiled at all. V., 3473.

Rolling the tar-putty filaments, in order to get a uniform diameter, requires a knack which only practice gives. V., 3480.

STABILITY:

Tar-putty filaments show no liability to rupture or displacement of parts during carbonization. V., 3469-70.

The carbon burners of incandescent lamps are practically stable under the conditions in which they are ordinarily used. No diminution in size can be detected after they have burned 1,000 hours, and they do not break on account of wearing away. V., 3475.

VACUUM:

The vacuum in the tar-putty lamps showed no depreciation at the end of the 600 hours' test, on account of the presence of gases in the tar-putty connections between the filaments and the platinum wires, since the gases had been removed by electrical heating during the exhaustion of the lamps. V., 3471.

IVES, Mrs. Ida Man:

is a daughter of Mr. Albon Man.

BURNER OF CARBON:

In the fall of 1878 I visited the shop in Walker Street and there saw five or six lamps burning, which had carbons a little longer than a half circle. My father, Mr. Man, told me that the carbons in the lamps were the same as those he made (McKeesport suit). II., 1161-2, **4641-2.**

CARBON:

In the spring of 1878 I assisted my father, Mr. Man, in preparing the carbons that he put into the crucible. I cut for him ordinary white blotting paper into narrow strips about an eighth or a quarter of an inch wide, and also cut rings about the size of the end of a spool of thread. My father also used sticks, which he filed down. These sticks were straight when put into the crucible (McKeesport suit). II., 1159-61, **4633-43.**

CARBONIZATION:

In the spring of 1878 I saw my father, Mr. Albon Man, making carbons for his electric light. He used a crucible, into which he put sticks and pieces of paper in the form of strips and rings, and some black-looking powder. He then placed the crucible in the range or laundry stove fire (McKeesport suit). II., 1159, **4633-4.**

JACKSON, F. E.

states that he is an electrician in the employ of the Edison Lamp Company.

CARBONIZATION:

The thread filaments of lamps in evidence were carbonized in a gas furnace, the same as the tar-putty filaments, except that no means of support for the thread filaments were adopted. When the carbonization was thought to be complete the gas was shut off and the furnace allowed to cool. V., 3501.

FILAMENT OF CARBON:

I have made lamps of cotton and linen thread, having filaments made in a spiral form and secured by the tar-putty composition to platinum tips before carbonization. Some of these lamps were made of thread rubbed with tar-putty. These lamps have been tested as to candle-power, voltage, amperes, resistance and watts per candle-power. V., 3497.

It is not necessary to restrict the radiating surface by close coiling, in order to obtain a lamp having the surface and resistance described in the patent in suit. Lamp No. 15 has resistance of 2,240 ohms, and the radiating surface, even if the filament were not coiled at all, would be less than three-sixteenths of an inch. V., 3498.

The carbonized thread filaments of lamps in evidence were all subjected to electrical heating on the pumps. V., 3500.

FILAMENT TAR-PUTTY:

The coal tar used in making the tar-putty filaments was employed just as it came from the gas works. V., 3497.

HEATING DURING EXHAUSTION:

The carbons of all the lamps in evidence made from carbonized thread were subjected during electrical heating on the pumps to a higher temperature than when tested for the data given in my statement. V., 3500.

RADIATING SURFACE:

It is not necessary to restrict by close coiling the radiating surface, in order to have a resistance and surface such as is described in the patent in suit. If the filament of lamp No. 14 were long enough to give a radiating surface of three-sixteenths of an inch, the resistance would be considerably more than 2,000 ohms. V., 3498.

JENKIN, Prof. Fleeming.

GEISSLER TUBES:

> "Electric sparks thus produced are said to overcome the resistance of the air, but this resistance has nothing in common with the resistance which is the subject of Ohm's law" ("Electricity and Magnetism," 1873. VI., 4393.

KNOWLES, Edward R.

is a civil and electrical engineer. Knew Mr. Sawyer in 1878, and is acquainted with the Sawyer-Man lamp, having been employed to make the drawing for one of their patents.

BURNER OF CARBON:

Never saw at Sawyer-Man's place, at 94 Walker Street, which I visited four or five times, any attempt to utilize any other substance than carbon as the incandescing conductor. H., 1149. **4595.**

I invented an incandescent lamp some time prior to October 12th, 1882, in which I used a variety of carbons, such as paper, kitool, tampico, istle, patent fiber, blast and bamboo (McKeesport suit). H., 1151. **4601.**

The Consolidated Electric Light Company finally decided, on March 28th, 1883, to use bamboo for the incandescing conductor. The bamboo carbons in the Knowles lamp had no lugs on the extremities, were much heavier, were round in section, were treated, and lower in resistance than the Edison bamboo carbons. The treating process was principally used to equalize the resistance of the carbons and make them uniform (McKeesport suit). The carbons in the lamps made by the Consolidated Electric Light Company were finer and longer than the carbon sticks given me by Mr. Sawyer. H., 1151-2. **4601-5.**

CROSS-SECTION:

Some time within four or five months subsequent to November 2d, 1878, Mr. Sawyer gave me some carbon sticks, from which I believe the illuminant in the Sawyer-Man lamp was made. The sticks were all about 1-32 of an inch in diameter. The illuminants in the Sawyer-Man lamp were from 1-64 of an inch to 1-32 of an inch larger than these carbon sticks. (Note. The increased size was the result of treatment.) H., 1145-8. **4580-9.**

HYDRO-CARBON TREATMENT:

The bamboo carbons in the Knowles lamps were of lower resistance than those of the Edison lamps, on account of being treated. The treating process was principally used to equalize the resistance of the carbons and make them uniform. H., 1151. **4603-4.**

LANE-FOX, St. George.

FILAMENT OF CARBON:

In a paper "On the Progress of the Electric Light," Crompton begins by saying: "I think there is little doubt that the year 1880 will be looked back to as a year of great progress in the introduction of the electric light. The commencement of the year was marked by the natural reaction in public feeling consequent on the disappointment which followed the collapse of certain famous promises with regard to lighting by electricity. People felt that little had been done towards solving the problem of the introduction of the new light into our streets and houses. A certain great name had been used as a lever by unscrupulous manipulators of the price of gas stock to unduly depreciate its value, and so produce a panic which had disastrous consequences to many holders." The author tries to give the credit for the modern lamp to Swan. In the discussion which followed the reading of the paper, Lane-Fox said: "I believe that Mr. Edison, who, of course, is referred to in the beginning of the lecture, though he is an American, has really done a great deal for this subject. He began a work, it is true, perhaps, rather got up, as it were, by speculators and gas people, but I think great credit is due to him for having stated from the very first that it was possible to introduce a system of electric light that could be so distributed and divided as to be available for household purposes. I think Mr. Edison was the first, and not Mr. Swan, to produce a practically useful lamp on the incandescent principle with a filament of carbon in a vacuum. Mr. Edison's researches, too, in respect to the presence of occluded gases in metals and other substances, are exceedingly interesting and very sound and scientific in the manner he has carried them out. I think he has rendered very great service, not only to the future of electric lighting, but also to science by his investigations, and for this proper credit should be given him, more especially as in the future he will be able to show, and I have no doubt will show, that he was the first to succeed and I think it as well to recognize it at once. I say this entirely disinterestedly, because it is very much to my disadvantage that Mr. Edison should be the first, as I have also claims in this direction." Crompton replied as follows: "In reply to Mr. Fox's remarks about Mr. Edison, I may say that he misunderstood me if he thought I cast any slur upon Mr. Edison as an inventor; I did not. What I blame Mr. Edison for was allowing his name to be used as a lever. * * * Of course, the fact that Mr. Edison has always been put forward as the leader in electric light invention has, to use an American expression, 'rose' people a great deal in England; but I will not say anything further about Mr. Edison." (Remarks on Crompton's paper "On the Progress of Electric Light," of January 26, 1881.) VI., 4256-62-74 and 4278.

LAMP, INCANDESCENT:

"It would not be possible for me to enter fully into details of the method of producing light by the incandescence of a continuous conductor of some refractory material. Suffice it to say that, although the devices for so obtaining light are still very crude and imperfect, there is not the slightest doubt that they will be very soon perfected. (Letter to "London Times," published December 26, 1878.) IV., 2184.

LODGE, Dr. Oliver J.

GEISSLER TUBES:

"There is no true conduction through either gases or vapors; in other words, a substance in this condition seems to behave as a perfect insulator. Not even mercury vapor is found to conduct in the least ("Nature" for 1887). VI., 4390.

LUVINI, Jean.

GEISSLER TUBES:

"Under all pressures and at all temperatures, gases and vapors are perfect insulators." "To suppose, as is generally done, that very rarified gases or gases at very high temperatures are conductors is a mistake due to confusion between resistance to disruptive and conductive discharges" ("Nature" for 1886). VI., 4389.

MAN, ALBON:

is a lawyer. Was associated with William E. Sawyer in the Sawyer-Man patents. Was a trustee, and at one time President, of the Electro-Dynamic Light Co.

ART, HISTORY OF:

Before Mr. Sawyer and I met, in January, 1878, we both knew that attempts had been made by several persons to make incandescent lamps, which attempts we understood had met with more or less success. From that time forward until the fall of 1878, I did not know, and do not think Mr. Sawyer knew, of any persons engaged in such attempts, except ourselves. He heard, in September or October, 1878, of Mr. Edison's attempt to produce incandescent lamps by the use of platinum, iridium and other metallic conductors for the incandescent portion of the lamp, and in December, 1879, I heard for the first time that Mr. Edison was endeavoring to use carbon for the incandescent part of the lamp. Between January, 1878, and the fall of 1878 we thought, or at least I did, that we were the sole persons then working at the matter. Prior to January, 1878, I do not think that I ever knew of any other form of carbon conductor than a straight pencil having been attempted to be used. Prior to January, 1879, I feel very confident that I had never heard of exhausting the nitrogen gas from the chamber of the lamp for the purpose of leaving a nitrogen atmosphere of a high degree of exhaustion in the lamp as a permanent atmosphere of the lamp. Where there was little or no atmosphere in the lamp, and that remnant was nitrogen. I believed then, and still do, that it was original with us (McKeesport suit). II., 951-4, **3802-3813.**

BURNER OF CARBON:

Different kinds of carbon were used almost exclusively as the material for the illuminating conductor of the electric lamps made by Mr. Sawyer and myself. II., 404, **1615.**

The burner in the lamp described in Patent 205,144, was from a quarter of an inch or less to three inches or more in length; in diameter, from less than one sixty-fourth to nearly one-tenth of an inch; the diameters and lengths varying, but some of the smaller diameters being of the greatest lengths. These dimensions apply to the carbon illuminants used in other lamps, except as to the shorter lengths. II., 404-5, **1616-7.**

The material of the carbon illuminants which we used was gas-retort carbon, electrically deposited carbon, carbons made by carbonizing fibrous materials, carbons made out of lamp-black and other carbonaceous materials

BURNER OF CARBON—(*Continued*):

cemented together by such substances as glue, tar, sugar, etc., and after being put into shape, carbonized; carbons made of plumbago, heated in like manner and ordinary pencil leads recarbonized. We used all kinds of fibrous substances we could get, such as different woods and fibers, and strings cut into shape and then carbonized; also paper and cardboard and ordinary cellulose, such as paper stock and papier-maché. Conductors were frequently made of the substances mentioned combined. As to forms, we used straight pencils of carbon, V-shaped pencils of carbon, arch-shaped carbons, like circular arches, elliptical or loop-shaped arches, arches with varying contour in the general form of the arch, as though the line of the arch was laid in waves, and arches of like shape with angular points in the line of the arch, and perhaps other forms. Some of the conductors of all these lengths and shapes were flat in cross-section; some elliptical and some round; some of them were in the form of a trough or U in cross-section; some of them tubular, and some, perhaps, of other forms. II., 405, **1619-20.**

We used for conductors papers of various kinds, all kinds of wood we knew of or could obtain, threads of different kinds, hemp, manilla, flax, jute, cotton, etc., and the separate fibers as they naturally occur in manilla jute. II., 406, **1623-4.**

As to the carbon illuminants made of powdered carbon mixed with tar, glue or sugar, or other carbonizable material, we mixed the materials into a thick paste, and rolled it out, for the most part, between metal plates. I also went to the Eagle Pencil Company and endeavored to have carbons made as they made lead pencils, by pressing the paste through a die. We also mixed the materials in a damp powdered state and pressed the mixture under a hydraulic press into the form of a thin sheet or cake, and then carbonized it. These sheets were cut into the desired shapes, such as straight pencils or arches, and then recarbonized. They were then usually, if not always, electrically treated according to our patented process. II., 407, **1626-8.**

In "Defendants' Exhibit Sawyer-Man Lamp No. 2," the carbon illuminant appears to be about five-eighths of an inch long. In its largest diameter I judge its total cross-section to be about a twentieth of an inch, its cross-section being somewhat like the letter U. The shell appears to be quite thin, of from two to three thicknesses of writing paper. It is made of deposit carbon, deposited by the electrical current upon a fibrous carbon which has been removed after the shell was cut away on one side; its resistance I cannot tell, but judge it to be only a few ohms, possibly four to ten. II., 410, **1637-9.**

In "Defendants' Exhibit Sawyer-Man Lamp for Horseshoe Carbon," we used an arch or U-shaped carbon. These carbons were almost all made of fibrous carbon, produced by cutting, or making into shape and size, wood, paper, strings, fibres, carbonized in a closed chamber packed in powdered carbon. II., 412, **1646.**

BURNER OF CARBON—(*Continued*):

The invention of "an incandescing conductor for an electric lamp of carbonized fibrous or textile material and of an arch or horseshoe shape," was made and reduced to practice in the month of March or April, 1878 (McKeesport suit). II., 436, **1744.**

The carbons that we made of excelsior were less than the thirty-second of an inch in diameter. Our carbons were from that size up to an eighth of an inch. The different sizes varied in length, for the reason that we had not sufficient electro-motive force to force a current through the smaller carbons and heat them up to incandescence. The longest were about two inches, possibly over two inches, and the shortest were down to a quarter of an inch. Those we made from willow twigs were split and shaved down, and the pith and bark were removed, the wood alone being used. With the exception of the excelsior, our wood and paper carbons were usually wider than they were thick. They were from a sixty-fourth of an inch up to a twentieth of in inch in thickness. Possibly some of them that were made from single sheets of paper were thinner than a sixty-fourth of an inch (McKeesport suit). II., 441-2, **1763-5.**

In order to make paper a conductor, so that a current could pass through it, we filled and covered it with plumbago. The practice we adopted in April, 1878, was to carbonize the paper without any such treatment before putting it in the boxes. It was covered with powdered carbon or powdered plumbago to protect it while being carbonized. We never treated any carbon made from paper or wood with plumbago after carbonization (McKeesport suit). II., 447, **1785-7.**

By the process described in Patent 317,676, we obtained a pure homogeneous carbon burner of exactly the length, form and size that we wanted—a burner that had also the necessary tenacity and density, and one in which the electrical resistance necessary to insure success could be exactly regulated. Upon a carbon burner having these properties depends the practical success of the incandescent electric lamp of to-day (McKeesport suit). II., 461, **1840-2.**

We used a great deal willow twigs and excelsior for making the fibrous carbons, and they made very good lamps. The large carbons differed only in size, length and resistance from the small carbons made of the same material. They did not differ in their properties as incandescent conductors (McKeesport suit). II., 464, **1853-4.**

The incandescent conductor used in the experiment at the Coal and Iron Exchange, in 1878, was a broken, angular splinter of gas-retort carbon, about a sixteenth of an inch in diameter and from five-eighths to three-fourths of an inch in length (McKeesport suit). II., 481, **1922.**

We tried and used the following classes of carbons for the incandescent conductors of our lamps: non-fibrous carbons, treated and untreated, and car-

BURNER OF CARBON—(*Continued*):

bons obtained by electric action. I certainly considered the carbon obtained from fibrous or textile material the best. I considered that it was improved by treatment as a conductor for an incandescent electric lamp for general purposes (McKeesport suit). II., 549, **2195-6.**

The incandescing conductor E. in Patent 205,144, had a cross-section of from one-twelfth to one-twentieth of an inch. I recollect one of a tenth of an inch cross-section. We used several kinds of carbons in these low resistances; among them French carbons treated and untreated; deposit carbons, pure and simple; also gas retort carbons and vegetable fiber carbons, treated and untreated. With all these carbons we made made lamps of less than one ohm resistance (McKeesport suit). II., 575-6, **2301-2.**

While at Centre Street, I think we set up and ran in the neighborhood of fifty to one hundred lamps having conductors of paper, or carbonized fibrous or textile material (McKeesport suit). II., 585, **2339.**

In our first attempt at carbonizing paper at Centre Street, we took a piece of blotting paper, which had not been carbonized, about an eighth of an inch wide, and a couple of inches long—a long narrow slip cut from a sheet of ordinary blotting paper. We laid this upon the table and put the terminals of the conductor down upon it. No current passed. We next drew a line with a piece of graphite on a piece of paper, put a little pile of graphite at each end of the line, pressed it down and placed the electrical terminals on the piles and endeavored to pass a current through it. Not succeeding, we increased the size of the line and approached the piles of graphite to each other at the extremities until the current finally passed along the line. Then we made an indentation in the paper and filled it with graphite. The current passed by a series of sparks along the line of graphite, and the paper was burned along the line and charred through to the under side of it. Mr. Sawyer was endeavoring by this experiment to show to me the advantages of a high resistance burner, and that with the electro-motive force that we had available we could send a current of sufficient strength through a very high resistance to heat it up to incandescence. No paper being charred or burned in the last experiment, we took a slip of paper, soft and porous, filled it with plumbago to the best extent we could, rubbed it with plumbago, pressed it, put it on the desk with a piece of mica underneath it, and applied the electrical terminals. The conductor remained incandescent longer than we had anticipated, and when it finally broke, and broke the electrical connection, portions of the charred paper took fire and slowly burned up. We were in trouble about getting carbons for incandescent conductors, and the thought occurred to both of us that we had hit upon a way in which such carbons could be produced of the size, shape and resistance which we desired, if we could prevent the consumption of the paper; we therefore proceeded to further experiments (McKeesport suit). II., 586-91, **2341-62.**

BURNER OF CARBON—(*Continued*):

Before trying paper we had been making conductors out of French carbons, in straight pencils, working down the pencils to make them small. We had also been making carbons out of thin sheets of French carbon, which we formed into an arch to rise above the holders of the lamps. We had great difficulty in working down these carbons to size and shape, such as we were then trying to use. We had certainly not determined on any fixed resistance or any fixed size of conductors, and we were trying different shapes of conductors (McKeesport suit). II., 591-2, **2362-5.**

In the first lamp made and run at Centre Street, the incandescent conductor was a pencil of retort carbon. The incandescent conductor was held by pressure between two metal supports in depressions made in them (McKeesport suit). II., 598, **2389-91.**

In Exhibit No. 3, the incandescent conductor is shown as extending straight across from one holder to the other; in some of our lamps of this type this conductor was of an arched-shaped or circular form rising above the tops of the holders (McKeesport suit). II., 621, **2483.**

In our first lamps used at Centre Street, the carbon was small pencils cut from rods of French carbon about the diameter of the smallest knitting needles—perhaps less than that—rods of that diameter (McKeesport suit). II., 622, **2487.**

Our second experiment with paper carbons consisted in filling the paper with graphite by soaking it in water in which graphite was suspended, and then drying it, and repeating the process until it was well filled with the graphite. More of this material was then rubbed into the paper after it was dry. The slip of paper thus prepared was placed in an electric lamp, and we tried to carbonize it by the heat produced by the current while in an inert atmosphere, used to prevent consumption. In these first experiments we used ordinary white blotting paper, perhaps an eighth or tenth of an inch wide, from one to three sheets thick, and with a total length of three-quarters of an inch to an inch. We got a current through this piece of paper; it was heated up, carbonized and broken, as we thought, by the shrinkage due to carbonization (McKeesport suit). II., 679-80, **2716-19.**

We soaked blotting paper in different mineral salts and partially reduced the salts, so as to make an electric conductor, using them in the same manner as those filled with plumbago. We heated them up by the passage of the current and carbonized them, but not with as good success as with the slips filled with plumbago. In neither case did the carbons last more than a moment or two before breaking. Those filled with plumbago lasted the best, and the carbons, aside from breakage, seemed to be of good quality. Up to the time when we carbonized paper in a furnace in a closed box, we had not succeeded in making a practical conductor in an incandescent lamp out of fibrous or textile material (McKeesport suit). II., 680-1, **2719-23.**

BURNER OF CARBON—(*Continued*):

The carbons cut from the first paper which we carbonized in the furnace, were from a quarter of an inch to three sixteenths in length, their width from a twelfth of an inch, or less, to half an inch, and their thickness that of the sheets from which they were cut. The length is only that of the incandescent portion, to which should be added the thickness of the holders—perhaps six-sixteenths of an inch—to make their total length (McKeesport suit). II., 689. **2755-6.**

While at Centre Street, we considered the best carbons to be those from willow wood, paper, and I think from broom corn. Of the paper carbons, we had best success with those from white blotting paper. Before carbonization, we sometimes soaked the paper in sugar, and we always compressed it. I think we also impregnated the materials with different carbonaceous substances, &c., to reduce the resistance of the carbons after they were carbonized (McKeesport suit). II., 718. **2870-2.**

We thought the arrangement of fibers in the paper carbon was an advantage, and we also thought its being in flat, thin sheets and easily put or cut into shape before carbonization was an advantage. Both the willow and the paper, being pure carbons, or substantially so, were most advantageous and proved the most successful carbons in use in our lamps. We also thought their fibrous structure, retained after carbonization, was an advantage. We also found that these substances were best carbonized without fracture (McKeesport suit). II., 725, **2898-9.**

In willow carbons the fibers run in the direction of the length of the conductor: it is a pure material, made a pure carbon, and was conveniently got into shape. The advantage of fibrous structure after carbonization consisted in strength and resistance to fracture in the direction of the length of the fiber, and possibly at right angles, or other directions; possibly elasticity or flexibility, or both. The incandescent conductor, made from fibrous or textile material, taking into account purity, practicability, cheapness and ease of manufacture, of proper size and length, was, on the whole, the best that I had known (McKeesport suit). II., 726-7. **2902-6.**

We found upon first using paper that it was too fragile; we obviated this in part by cutting conductors to shape and size before carbonization; in part by better carbonization of the conductors so cut to shape and size, and in part by modifying our lamps; in part we rendered the conductors sometimes and usually, but not always, less fragile, harder and denser, by an electrical treatment (McKeesport suit). II., 739. **2953.**

I do not recollect that we made any lamps in which the carbon was of single manilla fiber; we did make some in which the carbon was of twisted manilla fiber in the form of loops; they did not last any better, if as well, as the paper and wood carbons; they were more difficult to make and

BURNER OF CARBON—(*Continued*):

use, and we did not continue to make them, preferring the others. The same is true of jute, except that we did not like the jute as well as the manilla (McKeesport suit). II., 748-9, **2992-3.**

The excelsior carbons were mostly too fine and high resistance for our current, and we did not make much use of them; their use was experimental (McKeesport suit). II., 749, **2995.**

Note. Compare what Mr. Man says on pages 438 and 442 as to excelsior.

We bent and carbonized broom corn in the form of loops for conductors, but I do not think we saw any advantage in it, and I remember it only as a thing we tried experimentally (McKeesport suit). II., 749, **2996.**

Note. On page 718, Vol. II., Mr. Man says: "The three (materials) from which we met the greatest success, and which were preferred by us, in the order of preference, at the time, were willow wood carbons, paper carbons and carbons from broom corn."

In the horseshoe lamp the carbons were mostly, if not entirely made from wood and paper. It may be that some few lamps were set up of this form, the burners of which were made from circular disks or rings turned from French carbon or sheets of gas-retort carbon; but I do not think so in lamps of this size or diameter of lamp chamber (McKeesport suit). II., 921, **3681.** [Compare Sharp's testimony, II., 3355.]

In the tulip shape lamp, the conductors were mostly small circular rings or loops, made usually of carbonized wood and paper, sized and shaped before carbonization (McKeesport suit). II., 928, **3711-2.**

If in 1878 and 1879 we had wished to use incandescent lamps in multiple arc with an economy of ten lamps of sixteen candles each for each horse-power of current, and to attain the best duration of which we then had any experience, we should have selected willow and treated the carbons (McKeesport suit). II., 944, **3775-6.**

The first lamp that I knew of, having an incandescent burner in a shape other than that of a straight line or pencil, was made by Sawyer and myself in 1878. Subsequently, in 1880, I heard that some years prior to 1878 others had made burners of platinum of a form other than straight pencils (McKeesport suit). II., 956, **3821-2.**

CARBON:

Of the two specimens of carbon produced by me as part of a lot used by Sawyer & Man in the 1878 lamps, the longer is a little over twelve and a half inches long, the shorter about eight inches long; their diameter is as near a thirty-second of an inch as I can measure. II., 411, **1641.**

CARBON—(*Continued*):

The advantages of the fibrous or structural character of the carbon were mainly, as I conceived them, flexibility, elasticity and strength, the same being due to the fibrous arrangement—possibly to the material of which the carbon was made, being produced by a process of nature and some arrangement of molecules or atoms in such process (McKeesport suit). II., 735, **2938-9.**

We took into consideration the purity of the fiber to be carbonized. Our rule was to get cellulose as pure as possible, in which there was nothing but gases and carbon, particularly no metals nor their bases. Another thing was to get a dense fiber, or one that was not too porous; another thing was to get a fiber that was uniform and that could be easily worked and put into shape before carbonization. I do not know of any experience or rules of others at that time, except as to the infusibility of pure carbon (McKeesport suit). II., 942-3, **3767-9.**

CARBONIZATION:

The horseshoe form of carbon used in "Defendant's Exhibit Sawyer-Man Lamp for Horseshoe Carbon," was produced by cutting to shape and size and carbonizing in a closed chamber packed in powered carbon. II., 412, **1646.**

At first we carbonized the paper in sheets; sometimes several sheets stuck together and pressed, from which, after carbonization, we cut pencils and arches. After cutting them into shape, we placed them in boxes and crucibles in powered carbon or plumbago, or both, in alternate layers of the carbon powder and of the papers or other substances to be carbonized, until the boxes were filled. They were then pressed down, covered up, and the covers fastened down, then placed in the fire and heated until carbonized. After being carefully cooled, the boxes were opened and the carbon taken out. The wood carbons were carbonized in the samə manner. We also soaked them in sugar in some instances, and frequently, when we did so, recarbonized them in a box or crucible (McKeesport suit). II., 439, **1752-5.**

We used at first iron boxes about three or four inches in size and two inches deep, with iron covers. We used these boxes up and got a sand crucible to carbonize in. We luted them with fire-clay in the angles and around the cover. We also luted on the cover of the crucibles, leaving a small orifice in each case for the escape of gases. We put at the bottom of the crucible a layer of powdered carbon or plumbago and pressed it down hard. We then put in the articles to be carbonized, sometimes bending the wood into the shape we wanted it, and pressing it edgewise into the carbon powder. We then sifted more powdered carbon or plumbago into the box or crucible, until the articles were covered, when we again pressed it down and smoothed it off; packed in some more articles and so on until the box was filled, the last layer being a thick layer of powdered carbon

CARBONIZATION—(*Continued*):

pressed down solid, on to which the cover was pressed down. By way of experiment, we filled paper before it was cut to the size that we wanted it with plumbago, and polished it, rubbed it down and pressed it, and then cut it to size and put it into our lamps in an atmosphere of hydro-carbon, and passed a current through it to carbonize it. We also, by way of experiment, filled paper with sugar of lead and other mineral salts of easy reductions, soaking them in solutions of the salts, and after drying them and exposing them to an atmosphere of some sort, to partially reduce the mineral salts to make them conductors, we carbonized them in the same manner in the atmosphere of hydro-carbon; but these were only experiments, and we did but little of it. The first experiment with paper was made in the open air, by filling a crease in the paper with plumbago and passing the current through it. Afterwards we filled the paper with plumbago, pressed it, cut it into strips, passed the current through it, and burned it up. These were our first experiments in March, 1878 (McKeesport suit). II., 440-1, **1757-62.**

Up to the time when we carbonized paper in a furnace in a closed box, we had not succeeded in making a practical conductor for an incandescent electric lamp out of the fibrous or textile material. We practically could not carbonize with the current as we used it. We simply succeeded in producing a good quality of carbon, not a good illuminating conductor; with the mineral salts we did not get a good carbon (McKeesport suit). II., 681, **2723-4.**

In carbonizing in the iron box the paper was not treated in any way, except where more than one thickness of paper was used; in that case, sugar, molasses or treacle, was used solely as a glue between the layers of paper, which were pressed and dried (McKeesport suit). II., 684, **2734-5.**

In the second carbonization at my house, the material to be carbonized was cut to the desired shape and size to make a conductor before carbonization. I think the wood and paper were contained in the same box. The willow was ordinary willow, such as is used by basket makers, and was cut into straight pencils: the object was to make an incandescent burner of willow charcoal (McKeesport suit). II., 713-5, **2852-3** and **2857.**

At 94 Walker Street we did carbonization, though I probably did some at my house. Among those who would remember are Mr. George Sawyer and Mr. Sharp (McKeesport suit). II., 792, **3166-7.**

Note. Sharp testifies that he never saw carbonizing done at Walker Street more than three or four times, and never knew of any of the contents of the crucibles being used in any lamps. Vol. V. 3358. George Sawyer says he never saw anything but willow twigs carbonized there, and these did not amount to anything, being of too high a resistance for their machines. II., 3317.

CLAMPING:

In some cases where straight pencils were used, we bored holes for the reception of their ends in the holders, packed them with powdered carbon wet with sugar or syrup, or like substance, which, when the current was turned on, was carbonized in connection with the conductor; where arched carbons were used, we placed this same carbon paste between the clamps, and when they were screwed down, the conductors were imbedded in it, and it was carbonized by the heat of the current when turned on; we also treated them electrically before placing them in the lamps, as shown in our patent. II., 419, **1674-5.**

In the first lamp made and run at Centre Street, the incandescent conductor was a pencil of retort carbon. The incandescent conductor was held by pressure between two metal supports in depressions made in them (McKeesport suit). II., 598, **2389-91.**

Modifications were made by cutting off the tops of the holders, and pieces of carbon rod, in some cases square, and in some round, were substituted for the metal tops of the holders; at first these were fastened to the leading-in conductors by being wired to them, afterwards by drilling the metal tops of the holders and inserting the rods of carbon into the hole thus drilled in the metal, so that the carbon tops of the holders extended above the metal of the leads or leading-in conductors. At first the carbons of the incandescent conductor were inserted at their ends in pits drilled in the carbon holder. Afterwards a groove was made across the top of the carbon holders sufficiently deep to receive the incandescent conductor, which was laid in this groove across the tops of the two holders and packed in with powdered carbon; with this form of holders carbons of an arch shape were used, rising above the tops of the holders; a modification of the tops of the holders was also made, omitting the grooves just mentioned and making grooves in the tops of the holders at right angles to those last mentioned, to receive the ends of flat arch-shaped conductors. Another modification was made in the tops of the conductors by omitting the grooves and filing notches out of the inside tops of the opposing conductors, to receive flat arch-shaped conductors. Another modification was to split the tops of the carbon conductors to a depth of about three-quarters of an inch, cut off one side of the top of each conductor, drill through the remaining portion of the top and the piece cut off, insert in the drilled hole a small bolt with a nut, so that the piece could be used with a bolt, and not as a clamp, for holding the ends of the conductors. Another modification, where other than ordinary illuminating gas was used as an atmosphere, was, after the incandescent conductors had been placed in the holders, to run these conductors up to the high incandescence in an atmosphere of hydro-carbon, usually illuminating gas, first to heat the conductors, and second by deposit of carbon, to perfect their electrical connection with the holders, then take off the globe of the lamp, leaving the works all attached to the glass base, cleanse and purify all the parts,

CLAMPING—(*Continued*):

set them upon the globe again and charge the lamps with the atmosphere or vacuum we wished to use (McKeesport suit). II., 615-7, **2459-65.**

As the platinum tips in the lamps used at Centre Street heated and fused, we introduced a side circuit, or circuits with a switch, to turn more or less resistance into the side circuit, so as to turn more or less of the current into the lamps, and in some measure compensate for or regulate the variable current coming from the dynamos, so that we should not get in the lamps at any time current sufficient to fuse the platinum of the holders, or establish electric arcs between the holders and the carbon (McKeesport suit). II., 626, **2501-2.**

In our first lamps at Centre Street we endeavored to remedy the production of arcs by inserting the ends of the carbon more deeply in the holders, and we endeavored to form a deposit of carbon at the ends of the incandescent conductors, to make better electrical connection between them and the holders. We packed powdered carbon paste in the holders around the ends of the incandescent conductors, to make better connection; we enlarged the ends of the incandescent conductors by using larger carbon rods from which to make them, and by working them down small between the enlarged ends (McKeesport suit). II., 627, **2507-8.**

We frequently took down good lamps, because, by reason of the formation of electric arcs at the points of contact, we found that such contact had not been made perfect electrically (McKeesport suit). II., 936, **3743.**

COMMERCIAL SUCCESS:

We had most urgent requests to sell lamps with short, thick, low-resistance conductors (McKeesport suit). II., 583, **2332.**

I do not remember or know of any sales of any of our lamps, unless it be some lamps that were furnished to Messrs. Wallace of Ansonia in March, April or May, 1879, for which, I believe, they paid Mr. Sawyer subsequently—if that may be considered a sale. They were for sample lamps (McKeesport suit). II., 958, **3830.**

CROSS-SECTION:

The burner of the lamp described in Patent No. 205,144, was from a quarter of an inch or less to three inches or more in length; in diameter, from less than one sixty-fourth of an inch to nearly one-tenth of an inch; the diameter and length varying, but some of the smaller diameters being of the greatest lengths. These dimensions apply to the carbon illuminants used in our other lamps, except as to the shorter lengths. II., 404-5, **1616-7.**

CROSS-SECTION—(*Continued*):

Some of the burners made by us were flat in cross-section, some of them elliptical in cross-section, some round, some in the form of a trough and some of them tubular in cross-section. They were not always of the same form throughout the length of the conductors; thus tubular or U-shaped conductors throughout their main length were sometimes solid, and round or flat at the ends; the flat conductors throughout their main length were sometimes round at the ends, or with enlarged ends, or more widely flattened, or both. II., 405-6, **1619-21.**

In "Defendant's Exhibit Sawyer-Man Lamp No. 2" the carbon illuminant appears to be about a twentieth of an inch in diameter, the cross-section being somewhat like the letter U. II., 410, **1638.**

In the Sawyer-Man Horseshoe Lamp the cross-section of the illuminating conductors varied from that of a circle one-twentieth of an inch in diameter down generally, I should judge, to one-fortieth of an inch in diameter, and in some to a sixty-fourth or less in diameter. II., 412-3, **1648-9.**

The carbon in the Sawyer feeder lamp was somewhat less than a thirty second of an inch in diameter. II., 422, **1685.**

The carbons that we made of excelsior were less than a thirty-second of an inch in diameter. Some were as large as one-eighth of an inch. Our wood carbons were from a sixty-fourth up to a twentieth of an inch thick. Probably some of them that were made from single thickness of paper were less than a sixty-fourth of an inch (McKeesport suit). II., 441-2, **1763-1765.**

When we wanted a thick carbon we stuck together several thicknesses of paper. When we wanted a thin or fine carbon, we made it of a single thickness, or a less number of sheets stuck together (McKeesport suit). II., 465, **1857.**

The burner used in the experiment at the Coal and Iron Exchange, in 1878 was a broken, angular splinter of gas retort carbon, about one-sixteenth of an inch in diameter and from five-eighths to three-quarters of an inch in length (McKeesport suit). II., 481, **1922.**

It was known to electricians, in 1878, that increasing the size or section of a conductor diminished its resistance (McKeesport suit). II., 575, **2299.**

The carbon burner E, in Patent 205,144, was less than half an inch in length, and more than a twentieth of an inch in cross-section; I should say between a twelfth and a twentieth. I recollect one of a tenth of an inch cross-section. This conductor had a resistance of a fraction of an ohm (McKeesport suit). II., 576, **2301.**

CROSS-SECTION—(*Continued*):

(NOTE. Compare this with what Mr. Man says in answer to question 8. II., 404.)

In the lamps that we made having forty or fifty ohms resistance, my impression is that the burners were two inches or more in length, and less than a thirty-second of an inch in diameter (McKeesport suit). II., 577, **2304-5.**

Following the Patent No. 205,144, I think a person could use an incandescent conductor two inches in length and a thirtieth of an inch across, and my recollection is that we did so (McKeesport suit). II., 577, **2307-8.**

In the lamps shown in Patent 210,809, the diameter was from a tenth of an inch or more to a thirty-second of an inch or less (McKeesport suit). II., 583, **2330.**

In our first lamps used at Centre Street, the carbon was small pencils cut from rods of French carbon about the diameter of the smallest knitting needles—perhaps less than that—rods of that diameter (McKeesport suit). II., 622, **2487.**

The consumption of the carbon we attributed to the impurity of the atmosphere in the lamps ordinarily, or, in cases other than that, to using too great a current, so as to cause arcs where they would not occur with a proper current. In other cases, fracture occurred by putting too great a tension or pressure upon small carbons. In view of the fact that the carbon conductor of such a lamp as is shown in Patent No. 205,144, had to support the weight of the sliding mechanism, carbons of the smallest size could not be used in lamps of this form (McKeesport suit). II., 636 and 60, **2545** and **2639-40.**

NOTE. On page 404, Vol. II., in answer to question 8, Mr. Man testifies that the diameter of the carbon illuminant used in the lamp described in Patent 205,144 was less than $\frac{1}{64}$ of an inch (.015 in.). This is the smallest carbon that he has ever mentioned.

In the lamp described in Patent No. 205,144, the smallest carbons used were from a thirtieth to a fortieth of an inch in diameter (McKeesport suit). II., 663, **2649.** [NOTE: Compare Vol. II., 404, **1616.**]

In the lamp described in Patent 210,809, we used carbons as small as one-sixty-fourth of an inch in diameter, but they may have been larger. I think the nearest approximation would be a thirty-second of an inch in diameter (McKeesport suit). II., 664, **2654-5.**

CROSS-SECTION—(*Continued*):

The lamps described in Patents Nos. 205,144, and 210,809, were not well adapted to the smallest carbons (McKeesport suit). II., 670, **2677.**

In our first experiments with paper carbon, we used ordinary white blotting paper, perhaps an eighth or a tenth of an inch wide, and the thickness of from one to three sheets of the blotting paper, and of a total length from three-quarters of an inch to an inch between the holders (McKeesport suit). II., 680, **2717.**

The width of the first carbons cut from paper carbonized in the furnace was from a twelfth of an inch or less to half an inch, and their thickness, that of the sheets from which they were cut (McKeesport suit). II., 689, **2754.**

Of the carbons cut from paper in our first experiments, those of the largest cross-section, the thickest or widest or both, could be run at incandescence by our dynamo. The larger the carbon, the more brilliant the incandescence (McKeesport suit). II., 694, **2775.**

The paper carbons that were of too high resistance for the current that we had were less than a thirty-second of an inch thick—the thickness of carbonized blotting paper—and, approximately, one-sixteenth of an inch wide, perhaps less than that, and of a length of one inch or more (McKeesport suit). II., 713, **2850.**

DISTRIBUTION OF ELECTRICITY:

At the time of the application for Patent 317,676, we had not settled upon any system of arrangement of lamp to the exclusion of all others, that is, as to whether they were to be arranged in series or in multiple arc, or in some other way (McKeesport suit). II., 571, **2281.**

DURABILITY:

I don't know how long the carbons would endure in the state of incandescence at which it was designed that they should be illuminated, but some of those we made in October or November, 1878, were perfectly good lamps and showed no signs of deterioration or injury when we broke up our shop in the spring of 1879. They had been put to very hard usage; run to very high incandescence day after day, for weeks and even months, almost continually from the time they were made until we broke up the shop in the spring of 1879. II., 418, **1670-1.**

Note. Compare G. W. Sawyer's testimony on this point. Vol. V., page 3310.

In the experiment at the Coal and Iron Exchange, in 1878, the conductor did not remain incandescent more than ten or fifteen minutes at a time. It was lighted several times, the carbons being changed, and the flask refilled with gas each time it was lighted (McKeesport suit). II., 482, **1925-6.**

DURABILITY—(*Continued*):

If a lamp were constructed of high resistance according to Patent 205,144, it would probably not be so durable as a low resistance lamp (McKeesport suit). II., 579, **2313.**

I think I have known a conductor like that in Exhibit No. 1 run at incandescence longer than two or three hours (McKeesport suit). II., 632, **2528.**

In many cases, in lamps constructed according to Patent No. 205,144, the carbons were fractured, and in others some consumption at the ends occurred. The fracture and consumption were considered accidental by us, and it was to compensate, as far as possible, or provide against accident, that the carbon fed down upon the block D (McKeesport suit). II., 635-7, **2538-48.**

The consumption of the carbon we attributed to the impurity of the atmosphere in the lamps ordinarily, or, in cases other than that, to using too great a current, so as to cause arcs where they would not occur with a proper current. In other cases, fracture occurred by putting too great a tension or pressure upon small carbons. In view of the fact that the carbon conductor of such a lamp as is shown in Patent No. 205,144, had to support the weight of the sliding mechanism, carbons of the smallest size could not be used in lamps of this form (McKeesport suit). II., 636 and 60, **2545** and **2639-40.**

Note. On page 404, in answer to question 8, Mr. Man testifies that the diameter of the carbon illuminant used in the lamp described in Patent 205,144 was less than $\frac{1}{64}$ of an inch (.015 in.). This is the smallest carbon that he has ever mentioned.

In all our lamps some expedient was used to compensate for and prevent the injurious effects of expansion and contraction of the incandescent carbons, sometimes one device and sometimes another. We had made a few lamps at the time of the application for Patent No. 205,144 (May 16th, 1878), employing a straight stick of carbon rigidly attached to the holders. The carbons in these lamps usually broke the second or third time they were lighted up. They broke so soon as to make them practically inoperative for those uses where a lamp was required to be used with the same carbon and in the same atmosphere, beyond its first, second or third lighting up (McKeesport suit). II., 655-7, **2620-28.**

In the lamps described in Patent No. 205,144, we found it important to turn on the current gradually, because we were using a lamp filled with gas, and because the carbon was suddenly broken when the current was turned on suddenly at full force (McKeesport suit). II., 679, **2713-4.**

The carbons made from paper filled with plumbago or mineral salts lasted but a moment or two before breaking (McKeesport suit). II., 680, **2720.**

DURABILITY—(*Continued*):

I know that many of our paper carbons untreated were destroyed (as Mr. Sawyer states in the Interference Record), in from one second to ten minutes (McKeesport suit). II., 744, **2976.**

I have no reason to criticise Mr. Sawyer's statement in the Interference, that the treated carbons when run at about twenty-five candles, would last from five to twenty-five hours (McKeesport suit). II., 746, **2983.**

Note. Compare with this Man's statement, Vol. II., 418, **1671,** that their lamps had been run to very high incandescence days, weeks and months continually.

DYNAMOS:

I cannot give the size of the wire on the armature of the machine that was wound for us, nor the resistance of the armature and field: nor can I say in what manner the circuits in the machine were connected up. I guess the electro-motive force was some twenty-five or thirty volts: it may have been much more, or it may have been less. I don't think it was very much more than five volts, but I do swear at the same time I don't know anything about it. I think the machines we used would probably be estimated from thirty to two hundred volts (McKeesport suit). II., 532-534, **2127-35.**

In running the conductors of our first lamps at Centre Street to incandescence, we used the arc-light machine in the basement (McKeesport suit). II., 623. **2492.**

As to the dynamo machine, I only remember the general fact that it heated up the carbons to incandescence; how many, whether one or more, and when more, how arranged, or what resistances were in circuit, I cannot remember (McKeesport suit). II., 699, **2796.** [Note: Vol. II., 624, **2494,** Mr. Man testifies that their lamps were coupled up in series, simple multiple arc and in multiple series.]

Note. Attention is called to the line of questioning and the answers on this and neighboring pages. Although the witness remembers the minute and numerous details of the experiments upon lamps which were made by Sawyer and himself, he is unable to give any positive information concerning the dynamo which supplied the current to operate them.

ELASTICITY AND FLEXIBILITY:

The advantages of fibrous or structural character of the carbon were mainly, as I conceived them, flexibility, elasticity and strength (McKeesport suit). II., 735, **2938.**

ELECTRO-DYNAMIC LIGHT COMPANY:

By the 1st of September, 1878, the Electro-Dynamic Company had ample means at its disposal to apply for and obtain patents for such inventions as we thought of value (McKeesport suit). II., 470-1, **1881.**

The Electro-Dynamic Light Company was formed pursuant to an agreement and understanding between Mr. Sawyer and myself, up to the time of its organization (McKeesport suit). II., 519, **2073.**

In the spring of 1879 the Electro-Dynamic Company granted an exclusive license to the Wallaces, of Ansonia, for the manufacture of all their patented appliances and inventions, and Mr. Sawyer went to Ansonia to superintend the manufacture. Mr. Sawyer was paid by the stockholders of the company. But his habits were such that they could not get along with him, and Mr. Wallace finally turned him out, and went on with the work with Mr. Myers in charge. In the fall of 1879 Mr. Myers was taken sick and died. The matter lingered along, and no work was done by or under the Electro-Dynamic Light Company, until finally a consolidation was made with the Eastern Electric Manufacturing Company, and the patents and inventions were assigned to that company, and the Messrs. Wallace surrendered their license (McKeesport suit). II., 798-9, **3190-3.**

Under the agreement with the Wallaces, they were to manufacture and sell under all the patents of the company, and were to pay three dollars royalty per lamp, as compensation for the use of all the inventions. The royalty was limited to the lamps as first set up or installed, and not to renewal lamps or plants which they had previously set up and supplied with lamps (McKeesport suit). II., 874. **3495.**

Sawyer, having fallen out with Messrs. Wallace, returned to New York in the month of September, 1879, in a very antagonistic frame of mind, and demanded a license under the patents to go on and manufacture, although he knew the Messrs. Wallace & Sons held an exclusive license from the company. This was refused him. Thereafter he devoted himself to active antagonism to the Electro-Dynamic Company and its interests in every way. In the early part of 1880 he succeeded in organizing an opposition company, entitled the Eastern Electric Manufacturing Company, and in the meantime he devoted himself to writing articles to the newspapers, which he told me were intended to injure the Electro-Dynamic Company and myself, and to belittle the work done by us, and in this connection he wrote a book entitled "Sawyer on Electric Lighting." Mr. Myers, who was the only one besides myself and Sawyer acquainted with our work, having died, an arrangement was made with the Eastern Electric Manufacturing Company. Mr. Sawyer promised to cease his hostility and work for the best interests of the patents. He soon quarreled with the Eastern Electric Manufacturing Company. To get the patents actively at work an arrangement was made with the American Electric Light Company, and the Consolidated Electric Light Company was the result of this union (McKeesport suit). II., 915-6. **3659-64.**

GASES:

In "Defendants' Exhibit Sawyer-Man Lamp No. 2," the globe was charged and exhausted as in Patent No. 210,809. II., 412. **1645.**

In the first lamp made and run at Centre Street, the atmosphere in the globe was ordinary illuminating gas (McKeesport suit). II., 598. **2392.**

In our first lamps at Centre Street, when we used ordinary illuminating gas, the deposit of carbon soon prevented the incandescence of the carbon. By pumping them out or exhausting them, we found that the incandescence was much longer preserved, but that, with the vacuum we got, the atmosphere was still not appropriate. We next tried hydrogen gas, because we had no nitrogen, and found it better than hydro-carbon gas.

NOTE. It is well to note in this connection what Mr. Edison says in his testimony, Vol. V., 3125, in answer to Q. 476, that a lamp filled with hydrogen gas at atmospheric pressure would give no light at all for one horse-power of electric current.

We next used nitrogen gas in these lamps, and found it the best. We found that there was danger of explosion with the hydrogen and hydro-carbon gas. I don't think we discovered any difference in these lamps charged with a hydrogen or nitrogen atmosphere, whether they were exhausted or not. We discovered that the construction was not suitable to the permanent preservation of any atmosphere, and we proved that hydro-carbon atmospheres were unsuitable (McKeesport suit). II., 631-2. **2522-7.**

In the lamp described in Patent No. 205,144, the pressure of the gas in the lamp, at the time of its sealing up, was the same as the atmosphere, but as soon as it cooled off, it was at less pressure than the atmosphere, because in its passage through the heated tube for purifying it, the temperature of the gas was raised, and the gas in the lamp at the time of sealing up was hot, and at a higher temperature than after it had cooled off. When the conductor was heated to incandescence, the heat would tend to force the atmosphere out of the lamp, and upon its becoming cool, the air would rush in, and therefore the lamp must be tightly sealed (McKeesport suit). II., 670. **2677-80.**

It was necessary to turn the current on gradually to those lamps in which the larger size carbons were used, and, where the lamps were filled with gas at or near atmospheric pressure, with any sized carbon (McKeesport suit). II., 678. **2710.**

In order to secure the removal of the atmospheric air in our lamp, it was necessary to pass nitrogen through the lamp until the atmospheric air was carried out of the lamp, by dilution, or substitution of nitrogen for the air, or by making use of a difference in the specific gravity of nitrogen

GASES—(*Continued*):

and air, introducing nitrogen into the upper part of the lamp, and driving air out of the lower part, and continuing the process until all the air was driven out and only nitrogen left in it (McKeesport suit). II., 954. **3814.**

HEATING DURING EXHAUSTION:

We heated up the outside of the lamp while the exhaustion was going on, and turned on a current of electricity and heated the carbon conductor up to high incandescence; the other parts of the lamp were also heated by this passage of the current to some extent. This method substantially was pursued by us down to the time Mr. Sawyer and I separated. II., 417. **1666-8.**

HYDRO-CARBON TREATMENT:

The conductors in one form of our lamp were sometimes from five to eight inches long. They were straight, round pencils varying from about a thirty-second of an inch to a fiftieth of an inch when finished, and were treated electrically. Each end of the conductor was connected and a current of electricity sent through it, throughout its whole length, heating it up to high incandescence in a hydro-carbon atmosphere, to cause a deposit of carbon upon it, according to the process of Patent No. 211,262, to Sawyer and Man. II., 406. **1622-3.**

In this treatment, if any imperfections exist in the contacts, the resistance being highest there, carbon would be deposited at that point and the difficulty corrected, or if not, the lamp was taken down, the contacts remedied by adjustment and packing around the ends, and the process of electric treatment was then repeated; we also, in some instances, especially with arched carbons, short-circuited them by a copper wire close down to the holders, throwing the main part of the illuminating conductor outside of the circuit, by reason of its high resistance as compared with the copper wire, so that the deposit went on, when treated electrically, only at the ends. II., 419-20. **1675-7.**

We almost always treated our carbons by heating them to high incandescence in a hydro-carbon liquid or gas. We got a better carbon by treating them, and were able to regulate its resistance so as to make the carbon in itself uniform in its resistance throughout its length, and at the same time make one carbon of the same resistance as another (McKeesport suit). II., 443. **1770-1.**

I cannot give any definite proportion of the number of carbons used by us that were treated with hydro-carbon. The number of untreated carbons was small in comparison with those that were treated (McKeesport suit). II., 447-8. **1788-9.**

In our work, the shell deposited upon the outside of the carbon was sometimes almost inappreciable, the main work of deposit being done within

HYDRO-CARBON TREATMENT—(*Continued*):

the pores of the carbon and at the points of highest resistance. When we desired to cut the carbon to pieces after treatment, I think the treatment was carried to the extent of depositing from a thirty-second to a sixty-fourth of an inch, or to one one-hundreth of an inch. The thick deposits were only made by us for the purpose of cutting the carbon to pieces lengthwise, or when the original slip of carbon on which the deposit was made was to be removed, as I recollect it now (McKeesport suit). II., 551. **2201-2.**

It is not true that we did not make any lamps in which the carbons were not treated. Our shop was lighted in whole or in part with lamps in which the carbons were not treated, and they were good lamps. But it is true that, in our pattern lamps, to which we desired to conform the lamps which we should make, these being our practical lamps, the carbons were treated (McKeesport suit). II., 559, **2233-4.**

At Centre Street we reached a positive conclusion, or opinion, that our electrical treatment of carbons, which increased the density and decreased the resistance of a carbon made from paper, was desirable, and we also had an opinion that it was a convenient way, and useful in making certain carbons, to treat them, before or after carbonization, in carbonaceous solutions or liquids; this reduced the resistance and increased the hardness and density. I should think almost all of our carbons, while we were in Centre Street, were thus treated, either by the treatment of the sugar or carbonaceous solution, or by electrical treatment in a hydro-carbon atmosphere, liquid or gaseous, or both (McKeesport suit). II., 723-4, **2891-3.**

In some cases the treatment of the fibrous carbons was very slight, hardly perceptible except under the glass; in other cases the treatment was carried on and repeated until sufficient deposit of carbon had been made to serve as a conductor after the removal of the original carbon, and the deposit carbon thus formed was sometimes by us split or cut into two or three conductors lengthwise and re-treated to make them of the size and resistance required. I do not remember carbons made from any other fibrous substances than paper and wood with this extremely large treatment, and most of those were of wood carbon, and some few of paper carbon cut in the form of arches. In some cases we treated only to an extent required to make several carbons of uniform resistance, and in other cases treated them for the purpose of improving the carbon, irrespective of the question of resistance; in some cases to manufacture conductors of pure deposit carbon. At Centre Street we had found that the deposit carbon had a tendency to fly to pieces or break like glass when suddenly heated up. We had found that carbons largely treated with deposit carbon were liable also to fly to pieces in the same manner when suddenly heated up, but that fibrous carbons treated to a less degree were not liable to do so. The extent of the treatment that we thought best

HYDRO-CARBON TREATMENT—(*Continued*):

simply gave a silvery or lustrous appearance to the carbon, instead of being black, as it was before treatment. The resistance was reduced in proportion to the extent of treatment. In many cases I know that the resistance was not reduced fifty or seventy-five per cent. (as stated by Mr. Sawyer in his Interference testimony), nor even three or five per cent. (McKeesport suit). II., 730 3, **2919-29.**

The point which we considered most advantageous in treatment of the fibrous carbon, was that extent of treatment which, while driving out the occluded gases and purifying the fibrous carbon in the treatment, would not interfere with or destroy its fibrous structure, but would leave it still a fibrous or structural carbon, with nothing but pure carbon added to it, and that not to such an extent as to interfere with the advantages of the fibrous or structural character of the conductor, nor to render it liable to the objections of the deposit carbon (McKeesport suit). II., 734-5, **2934-7.**

By the use of the hydro-carbon treatment we obtained three characters of carbon: first, a fibrous carbon in which the pores were filled up; second, a fibrous carbon treated to such an extent that the original carbon simply acted as a core for a shell of deposit carbon; and third, a deposit carbon, pure and simple, from which the fibrous carbon was removed. The second was more liable to fracture than the first, and not so liable as the last (McKeesport suit). II., 737, **2946-7.**

I think all the carbons were improved by the electrical treatment and rendered more durable (McKeesport suit). II., 744, **2973.**

In the two hundred lamps made in March, 1879, the fibrous material was mainly paper and wood. This was treated only so far as to leave the material still porous, and the coating was infinitely thin, except where points of high resistance were regulated in the process to make the conductor uniform in resistance throughout its length (McKeesport suit). II., 783-4, **3132-3.**

Mr. Sawyer and I, by our experiments, satisfied ourselves that good illuminating conductors for incandescent electric lamps could be made from fibrous material without treating them electrically. But we considered that they were improved by the electrical treatment, and therefore adopted the treatment of carbons as a general practice (McKeesport suit). II., 813, **3249-50.**

INVENTION INVOLVED:

On January 8th, 1880, I believed that the arch, or loop, or V-shaped burner was original with us, not only for carbon, but for all incandescing conductors of that form. It was for conductors of these forms only, that the contract with Mr. Cheever was made (McKeesport suit). II., 887, **3545-6.**

LAMP CHAMBER:

In the Sawyer-Man Horseshoe Lamp the glass part of the lamp consists of a tube, like a large test tube, with a flange at one end and the other end closed. What is called the base of the lamp consists of a round flat disk of glass, through which the leading-in conductors pass. The disk and flange are ground together until their junction seems as transparent as the rest of the glass. Tubular binding screws pass through the glass disk, having a solid flange on their inside part; the flange is ground down to the disk by revolving the binding screw until the metal and disk fit perfectly air-tight. Outside the disk, a nut threaded on the bolt is also fitted tightly to the glass. The interior works were then inserted. Between the flange and the glass, and the nut and the glass, are placed washers, sometimes of soft, metallic foil, and sometimes of thin paper, in either case the junctions being filled with Canada balsam sometimes, and sometimes left with nothing. The nut on the outside was then screwed up tightly. The base and outer end of the flange were varnished with a coat of Canada balsam, and the flange and base plate fastened together and thoroughly clamped together by metal rings and screws. The junction between the glass base plate and the flange was then covered with a preparation of tempered sealing wax. A spun metal cap filled with melted sealing wax with a small orifice in the end was then put over all, covering the tubular bolts and the glass next the ring and the whole thing, electrical connections being made, however, between the tubular bolts and these covers. The caps were in some cases screw-threaded on to the bolts; the orifice in the caps was soldered up where any existed. The bottom plate between the rings and bolts was then covered with melted sealing wax. Over all, a spun metal cap, covering all the base up to the top of the rings, was placed and filled with melted beeswax, or like substance. II., **415-6, 1658-64.**

We made our lamp chamber of two separate parts, because we wanted a lamp in which the incandescing carbon, if it should give out, could be readily and cheaply substituted, all other parts of the lamp remaining good. II., 426-7, **1704-5.**

We made two or three lamps in which the enclosing globe consisted of one single piece of glass, the leading-in conductor being inserted through holes bored in the walls of the glass chamber, the globe having no separate base as in the lamps put in evidence. We both knew about electric conductors being passed through, and sealed into walls of glass by fusion; also what metals were most appropriate, by reason of their coefficient of expansion being the same, or nearly the same, as glass. We likewise knew of the ordinary Geissler tubes in which conductors were sealed in the walls of a glass chamber, in which a vacuum was maintained, and where a light was produced in the chamber by the passage of electricity through the leading-in wires. We were acquainted with Crookes's experiments with the radiometer, and had seen radiometers in which the platinum conductors were passed through and

LAMP CHAMBER—(*Continued*):

sealed by fusion in the walls of a glass chamber in which a very high vacuum was maintained. We had both read of Crookes's experiments and seen drawings of his apparatus and descriptions of how it was made, and had frequently discussed these matters. We adopted, by preference, the lamp chamber of two pieces of glass. II., 427-8, **1706-9.**

At first the bottoms of the Sawyer-Man lamp chamber were made of plate glass perforated to admit the passage of the conductors. This was an expensive method, and we at once got a mould for making the bottoms with perforations through them, directly from the glass pots in the glass factory. After we got the mould, which was, I think, in March, 1878, we used the glass bottoms made from it (McKeesport suit). II., 453, **1811.**

In the fall of 1878, Mr. Sawyer got a glass blower, who had his place directly opposite ours in Walker Street, to fuse some of the bottoms on to the lamps and fuse glass tubes into the bottoms. The interior parts of the lamps were set up, and the glass tubes fused into the bottoms with the conductors in them before the bottoms were fused on to the globes. Mr. Sawyer also had some four lamps blown, in which there were no bottoms separate from the globes, but the conductors were led through the glass of the globes and fused in them, the parts of the lamp being set up inside it before this operation was performed. In that way an all glass lamp was produced having its several glass parts fused together with the leading-in wires fused in the glass. There were only a few of them made, and they were in operation at Walker Street in 1878. I do not know what became of these lamps; I think Mr. Sawyer took them (McKeesport suit). II., 454-5, **1815-20.**

Note. Later on (II., 934), Mr. Man says that *all* the lamps which were made while Mr. Sawyer and he were working together, were constructed so as to be readily taken apart.

We preferred to make our lamps with the bottom ground on to the globe of the lamp, for the reason that we could take them down and put them up as often as we pleased, and restore the incandescent portion of the lamps without injury to the rest of the lamps. We both knew, and often discussed the fact that the chamber could be made wholly of glass, having its several parts fused together (McKeesport suit). II., 457, **1827.**

I remember getting some glass globes with a neck and flange at the bottom end, which had stoppers ground and fitted into them level with the flange. These glass stoppers we ground more nicely, and I took them to a diamond cutter and had them perforated for the conductors. The conductors were tubular, flattened together at the upper end and brazed, with an orifice between the flattened portion. The carbons were held at

LAMP CHAMBER—(*Continued*):

first by the spring of the conductors (McKeesport suit). II., 609-11 **2429** and **2442-3.**

The object in using the glass globes with a neck and flange, was to obtain a better sealed chamber of glass than with the brass caps, and avoid insulating either of the leading-in conductors, otherwise than by the glass through which they passed. The form of the stopper and neck, in which it was placed, enabled us to cover the whole with sealing wax, which we did. Another object was to avoid separation of the parts by unequal contraction or expansion by heat, by making them all of glass (McKeesport suit). II., 612, **2445-6.**

A slight modification of the glass globes with a neck and flange consisted in closing up one end of the tubes of the leading-in conductors at the lower end, leaving only one opening into the lamp. This was done to enable us to charge the lamp by first exhausting and then allowing the gas to flow into the exhausted lamp, the open tube being branched outside of the lamp and fitted with stop cocks for that purpose. Another modification consisted in using an iron wire as the conductor, with a shoulder coming down upon the glass stopper inside the lamp, accurately fitted to the hole in the stopper, and with nuts at the lower side of the stopper. One of the conductors was drilled out so as to make it a tube opening to the air. Our next modification of this was in having the glass stoppers shouldered, so that the shoulder would rest on the neck of the bottle, in order that the atmospheric pressure, when the atmosphere was exhausted from the bottle or globe, would not force in the stopper and split the neck of the bottle. Our next modification was to use a plate of glass perforated for the conductors and ground and fitted to the flange of the globe, instead of the stopper. The plates of glass were ground with the flange until they were fitted tight (McKeesport suit). II. 612-4, **2446-54.**

At first, for bases, we got a few pieces of plate glass, some of them cut in circles, and some square. We perforated one of these for the conductors. We ground the face of the flange on one of the seed bottles with emery, to make it level and true, until we got it substantially polished. The plate glass was already true and polished. We then ground the flange and plate glass together until their junction was air-tight. We then set up the internal parts of a lamp upon the base (McKeesport suit). II., 620, **2477.**

We used the soapstone disk mentioned in Patent No. 205,144, because we found that the use of the disk and the long conductors, or conductors formed specially to radiate heat, prevented heating of the base of the lamp, and that perfect joints could be maintained by their use. In lamps where they were not used, the bottoms of the lamps became hot, and leakage did occur there sometimes, and sometimes breakage,

LAMP CHAMBER—(*Continued*):

when the lamps were run up to high incandescence (McKeesport suit). II., 677, **2707-8.**

Our usual method was to clamp the parts of the lamps together, not fuse them. We preferred to fit them together, so that we could take them apart and renew the carbons, and charge them or exhaust them (McKeesport suit). II., 761, **3041.**

We had blown, while we were at the corner of Centre and Howard Streets, a number of sizes of globes; as many, I think, as six or seven sizes different in diameter, and of great variety and length. They were mostly straight tubes, with a flange at the lower end like test tubes in shape, but some of them had round bulbs on the closed end of the tube. I did not like the shape, and a friend, an architect, drew for me the design of the tulip-shaped bulb. I took the design to a glass blower, and had about a dozen of the tulip-shaped bulbs blown. The lamps were set up in them, and run at our shop (McKeesport suit). II., 927. **3705-8.**

All our lamps, while Mr. Sawyer and I were working together, were made so as to be readily taken apart, so that anything could be readily done to the interior works of the lamps, such as substituting carbon conductors, or restoring vitiated atmosphere, or an atmosphere not suitable to the incandescent lamp (McKeesport suit). II., 934-5. **3736-7.**

It was our intention to make our lamps so that if the incandescent conductor should give out, the lamps could be opened and a new conductor put in (McKeesport suit). II., 959. **3835.**

If the parts of the lamp chamber had been fixed to each other, they could not have been taken apart and a new carbon put in without breaking the globe of the lamp (McKeesport suit). II., 959. **3836.**

LAMP, INCANDESCENT:

Edison's incandescent lamp embraces and includes an incandescent conductor for an electric lamp of carbonized fibrous or textile material and of an arch or horseshoe shape. When put in use it embraces and includes an incandescent electric lamp composed of the following elements in combination: first, an illuminating chamber made wholly of glass, hermetically sealed, and out of which all carbon consuming gases have been exhausted or driven; second, an electric circuit conductor passing through the glass walls of said chamber and hermetically sealed therein; third, an illuminating conductor in said circuit and forming part thereof within said chamber, consisting of carbon made from a fibrous or textile material and having the form of an arch or loop (McKeesport suit). II., 462-3. **1847-9.**

LEADING WIRES:

The leading-in wires of our first lamps made at Centre Street were copper rods, screw-threaded at the lower end; they were attached to the base and hammered out flat at the upper ends, and filed off to be of the same width, after hammering flat, as the diameter of the copper rods. One was simply screwed into the inside of the base; the other passed through an insulation in the base—had a hole through it in which to insert the electrical connecting wire outside the base with a binding screw to hold the wire. They were between a quarter of an inch and half an inch in diameter, and the flattened parts at the upper ends were about an eighth of an inch or less in thickness. These leading-in conductors were faced with platinum at the points where they held the ends of the incandescent conductors. These leading-in conductors, or holders, were about six inches in length inside the globe (McKeesport suit). II., 623, **2488-90.**

LENGTH:

The burner in the lamp described in Patent No. 205,144, was from a quarter of an inch or less to three inches or more in length. Those in one form of lamp were sometimes five to eight inches in length. The diameters and lengths varied, some of those of the smallest diameters having the greatest lengths. II., 404-5, **1616-7.**

In " Defendant's Exhibit Sawyer-Man Lamp, No. 2," the carbon illuminant appears to be about five-eighths of an inch long. II., 410, **1637.**

The length of the horseshoe carbon used in the Sawyer-Man lamp varied, between the clamps, or conductors, from three-quarters of an inch to between two and three inches, some perhaps longer than three inches; they were frequently made by us in the form of rings, about one inch in diameter and three and three-sevenths inches in circumference, but a part of this was clamped by the holders, leaving the incandescent portion rising above the holders somewhat less than three inches, outside length; some of these rings were less than inch in diameter, and some of the incandescent conductors were loops, and not rings. II., 412, **1647-8.**

The Sawyer feeder lamp provides for the use of a carbon about seven inches long, and somewhat less than a thirty-second of an inch in diameter. II., 422, **1685.**

In the feeder lamps the whole length of the carbons was in circuit. Only the part of the carbon was incandescent which was between the upper and lower holders. The length of the incandescent portion was usually about five-eighths to three-quarters of an inch, but it varied in different lamps, being in some from one and a half to two inches in length, not exceeding three inches. II., 431, **1721-2.**

The different sizes of our carbons varied in length, for the reason that we had not sufficient electro-motive force to force a current through the smaller

LENGTH—(*Continued*):

carbons and heat them up to incandescence. The longest were about two inches, possibly over two inches, and the shortest down to one-quarter of an inch (McKeesport suit). II., 441, **1764.**

In 1878 it was known to electricians that increasing the length of a conductor increased its resistance (McKeesport suit). II., 575, **2299.**

In Patent 205,144, the length was anything above the clamp G: a small fraction of an inch would be sufficient, but we used carbons of more than three inches total length, including the incandescent portion and the portion above the clamp, that is to say, the total distance from D to *a* (McKeesport suit). II., 577, **2307.**

The conductors in the lamps shown in Patent 210,809, varied from less than half an inch in length to three inches in length (McKeesport suit). II., 583, **2330.**

The longest carbons used in the lamp shown in Patent 210,809, was two inches. Of the smallest carbons the usual length was from half to three-quarters of an inch long (McKeesport suit). II., 664, **2655-6.**

The first paper carbon incandescing burners were of a total length of three-quarters of an inch between the holders; when placed in the lamp, about half an inch (McKeesport suit). II., 680, **2717-8.**

The first carbons cut from paper carbonized in the furnace, were from a quarter of an inch to three-sixteenths of an inch in length. This is the incandescent portion; to this must be added the thickness of the two holders, perhaps six-sixteenths, to make their total length (McKeesport suit). II., 689, **2755-6.**

MULTIPLE ARC:

Sawyer & Man had determined to use the same types of lamps both in series and in multiple arc, depending upon circumstances and the current available (McKeesport suit). II., 571, **2283.**

Our first lamps used at Centre Street were coupled up in series, in simple multiple arc and in multiple series (McKeesport suit). II., 624, **2494.**

RESISTANCE:

When we wanted to make conductors of high resistance, we were in the habit of working them down on a lap fully one-half or more of their size. II., 408-9, **1632-3.**

The resistance of the carbons used by me and Mr. Sawyer was extremely various. Its lowest limit was less than one ohm; the highest resistance

RESISTANCE—(*Continued*):

in our lamps I place at from thirty to fifty ohms. Before treatment I believe that their resistance was sometimes as high as one hundred ohms. II., 409, **1634-5.**

In "Defendant's Exhibit Sawyer-Man Lamp, No. 2," I should judge the resistance of the carbon illuminant to be only a few ohms, possibly four to ten. II., 410, **1639.**

In the Sawyer-Man horseshoe lamp the resistance of some of the carbons was less than one ohm. Some, prior to electrical treatment, were from 50 to 100 ohms, perhaps higher. After treatment they were from 30 to 50 ohms resistance. II., 413, **1649-50.**

By the hydro-carbon treatment we were able to make the carbon of the same resistance throughout its entire length, and also to make one carbon of the same resistance as another. When we wanted a carbon of high resistance, we made it small and long; when low resistance was desired, we made it larger or shorter, or both. The resistance might also be varied in the same material by carrying the carbonization to a higher degree, or at a higher heat, or at a lower heat. The resistance was also varied by the extent and manner of treatment subsequent to the making of the carbon. Carbons of uniform section and of the same character and density vary in resistance directly as their length. Of the same material, the resistance is decreased as the square of the diameter is increased. This is an electrical principle applicable to all conductors. There is no fixed point where a lamp, or the incandescing conductor of a lamp, can be said to be of high resistance or low resistance. The resistance may be anything from 200 to 300 ohms down to a fraction of an ohm. If the current is of high electro-motive force, then the lamp may have a high resistance; if the current is of low electro-motive force, the resistance must be reduced until sufficient current will pass through the incandescent conductor to heat it up, so as to give the required light. I intend to say that there is no point agreed upon among electricians at which high resistance begins and low resistance ends. The expression is purely comparative (McKeesport suit). II., 443-5, **1771-79.**

The resistance in the lamp described in Patent No. 205,144, might be anything, if proportioned to the current used. We did not think that it was necessary to give in the patent the resistance of the conductor. In the patent the resistance might be anything from the fraction of one ohm to one hundred and fifty ohms or more, if proportioned to the current, and be an operative lamp. At the time the application for Patent 317,676, was made Sawyer & Man had not determined upon any fixed or given resistance for their lamps (McKeesport suit). II., 568-570, **2271-80.**

Sawyer & Man had determined what the resistance should be for different currents and different arrangements of lamps, as these resistances varied in most cases of actual use; they had not determined or fixed upon one

RESISTANCE—(*Continued*):

certain resistance for all incandescent electric lamps, either approximately or positively. It is a question of currents available, but there is no such general practice as precludes the running of lamps of low resistance in multiple arc, or the running of lamps of high resistance in series, within the limits of practicability (McKeesport suit). II., 572-3, **2285-89.**

A lamp constructed under Patent 210,809, might or might not be of higher resistance than one constructed under Patent 205,144. It would depend upon the wish of the person constructing the lamp. A person could make a lamp of higher or lower resistance of either kind (McKeesport suit). II., 573, **2291-95.**

At the time Letters Patent 205,144, were granted, a person skilled in the art could construct a lamp according to that patent, and make his lamp either a fraction of an ohm or forty or fifty ohms resistance. It would simply be necessary, for the lower resistance, to make the conductor of carbon short and large and of carbon of high conductivity; in the case of high resistance, to make the conductors long and small and of carbon of high resistance. This would be known to a person then skilled in the art (McKeesport suit). II., 574-5, **2294-7.**

In 1878 the different qualities of French carbons, so called, were known to electricians to be of less resistance than the ordinary gas retort carbons. They were also known to be of less resistance than charcoal and vegetable carbon. I think the resistance of different carbons was tested by electricians before that time. It was well known to electricians that increasing the length of a conductor increased its resistance, and that increasing the size or section of a conductor diminished its resistance, and it was known that different carbons, of same size, section and length, had different resistances. (McKeesport suit). II., 575, **2298-9.**

We made lamps of less than one ohm resistance from the following carbons: French carbons, treated and untreated; gas retort carbons and some vegetable fiber carbons, treated and untreated; some of deposit carbon pure and simple (McKeesport suit). II., 576, **2302.**

We made lamps of forty or fifty ohms resistance. My impression is they were two inches or more in length, and less than a thirty-second of an inch in diameter (McKeesport suit). II., 576-7, **2304-5.**

It is true, as we state in Patent 210,152, that we had found the internal resistance of such a lamp as is described in Patent 205,144, to be not far from six-tenths of an ohm. It might be of any resistance, from less than one ohm, or of forty ohms. There would be more difficulty in making the higher resistance lamp. The high resistance lamp would probably not be so durable as the low resistance lamp (McKeesport suit). II., 578-9, **2309-13.**

RESISTANCE—(*Continued*):

Under Patent No. 210,809, a lamp could be made from less than one ohm up to forty ohms resistance (McKeesport suit). II., 579, **2314.**

The resistance in the lamps similar to that in Patent 210,809, varied from the fraction of one ohm up to fifty ohms (McKeesport suit). II., 583, **2330.**

At the time of making the first experiments with paper carbons, Mr. Sawyer had a decided preference for the higher resistance kinds of carbon. It was his opinion that the higher resistance carbons, within practical limits, were, or would prove, the best carbons for the incandescent conductor of an electric lamp. I thought that less resistance in the carbon than Mr. Sawyer thought would be desirable for the incandescent conductor of an electric lamp. In the first experiment in carbonizing paper we had not present in our mind the getting a higher resistance in the carbon due to the character and construction of the carbon (McKeesport suit). II., 693-4, **2768-9.**

We only succeeded in running to incandescence a few of our first paper carbon conductors. These were those of the least resistance; some of them were cut too narrow, and had too high a resistance for the current from our dynamos (McKeesport suit). II., 694, **2774.**

At the time of our experiments with the paper carbon conductors, we knew that, the current remaining the same, the incandescence of the lamp would be increased as its resistance was increased relatively to the total resistance in the circuit; in other words, that the work would be done where the resistance existed (McKeesport suit). II., 695, **2778.**

The carbons made from blotting paper, that we thought were of too high resistance for the current that we had, were less than a thirty-second of an inch thick, approximately one-sixteenth of an inch or more in width, perhaps less than that, and an inch or more in length (McKeesport suit). II., 713, **2849-50.**

At Centre Street we knew that the resistance of the conductors would be rapidly reduced by hydro-carbon treatment. We frequently treated the conductors in order to get them of the same electrical resistance. The resistance of the conductors was reduced in proportion to the extent of the treatment. I know that in many cases the resistance was not reduced (as stated by Mr. Sawyer in his Interference testimony) either fifty or seventy-five per cent., nor even three or five per cent. (McKeesport suit). II., 730-3, **2917-29.**

The resistance of our paper carbon burners being too high for the currents at our disposal, we reduced their resistance by treatment and by making them larger (McKeesport suit). II., 742, **2965.**

RESISTANCE—(*Continued*):

Our carbons were usually made of a resistance which would be equal to that of a well-made deposit carbon, having a length of from half an inch to three-quarters of an inch, and a diameter of a twentieth of an inch. (McKeesport suit). II., 743, **2971.**

The lamp which we had perfected when we left Centre Street, and designed at that time to introduce commercially, and the ordinary lamp that we built, had a large and low resistance carbon, in comparison with the incandescent lamp of the present day (McKeesport suit). II., 762 3, **3048.**

The two hundred lamps ordered to be made by the Electro-Dynamic Co. in March, 1879, were not approximately of one resistance, but varied from less than an ohm to more than thirty to fifty ohms, the majority being from one to five ohms. At the time these lamps were built I don't think we had agreed upon anything as a fixed desirable resistance (McKeesport suit). II., 787-9, **3145-54.**

RESISTANCE, SPECIFIC:

It was known in 1878, that different carbons had different resistances for the same size, section and length (McKeesport suit). II., 575, **2299.**

In our first experiments in carbonization of paper we did not have present in our minds the getting a higher resistance in the carbon due to the character and construction of the carbon (McKeesport suit) II., 693, **2769.**

SAWYER'S FEEDER LAMP:

Mr. Sawyer made in the fall of 1878 and winter of 1879, at 94 Walker Street, from a dozen to twenty lamps in accordance with Patent 219,771 (feeder lamps), and after we ceased working together, he made a set of eight or ten more. The feeder lamp is an incandescent lamp, pure and simple; the occurrence of an arc would destroy its operation for the time being, until the carbon conductor should be fed up intentionally to make contact with the upper holders or carbon rolls, by the electro-magnetic apparatus at the base of the lamp. The carbon used in the lamp was six or seven inches long; the construction of the lamp provides for the use of a carbon about seven inches long, and somewhat less than a thirty-second of an inch in diameter. II., 420-422. **1678-85.**

Our long lamp adapted to the arch form of carbon could have been manufactured and sold at a fair profit, at a dollar and a half to a dollar and seventy-five cents. The cost of the same type of lamp, but with straight pencil carbon, would be the same, or possibly seventy-five cents more. The lamp with the spiral conductors would cost from twenty-five to fifty cents more. The feeder lamp would cost $10 or $12, possibly $15, and the profit would have to be got on that (McKeesport suit). II., 959, **3833-4.**

SAWYER-MAN LAMP:

The several parts of the Defendants' Exhibit Sawyer-Man Lamp for horseshoe carbon were made in the fall of 1878. We made a large number of them. II., 414-5. **1655-7.**

I know that we produced good, practical incandescent lamps: so did Mr. Sawyer—I thought so then and think so now—and better lamps than are used to-day commercially: that is, they gave more light, and were run at higher incandescence by us ordinarily than the incandescent lamps ordinarily in use now. II., 418-9. **1672-3.**

We had at one time several sets of lamps of from six to twelve lamps in a set, perhaps eight as an average number, having loop-shaped carbons, that were good, practical lamps for commercial use; I estimate that we had three to five sets that were good commercial lamps. We made more straight-pencil lamps than loop-shaped; I think we probably made some hundreds of these lamps that proved good and practical. All the joint work done by Mr. Sawyer and myself was done between the sixth or seventh of March, 1878, and the last of March, 1879. II., 422-3. **1686 90.**

The lamps exhibited at Walker Street continued luminous for two or three hours at a time. II., 424. **1695.**

The lamp embodying the inventions which we made in the spring of 1878, was a thoroughly operative lamp (McKeesport suit). II., 462. **1845.**

The experiment at the Coal and Iron Exchange, in 1878, consisted in heating up a piece of platinum or a piece of carbon, I am not sure which, in a bottle filled with ordinary illuminating gas from the gas main by means of an electric current (McKeesport suit). II., 478. **1912.**

Note. Compare with this the exact description of the experiment which Mr. Man gives. Vol. II., p. 481.

At the time we were at Howard Street (September, 1878), we considered that we had a lamp that was practical and could be introduced commercially (McKeesport suit). II., 510. **2040.**

At the conclusion of the Sawyer-Man experiments we had agreed as to all the lamps and types of lamps which we intended to introduce, except one which we termed the feeder-lamp. My views and Mr. Sawyer's were not entirely in accord as to the comparative value of the different lamps which we considered good and intended to introduce. We considered the lamps shown and described in Sawyer-Man Patents Nos. 205,144, and 210,809, practical for commercial purposes, and we made a great many of them. They represent in whole or in part the type of lamp which we intended to introduce (McKeesport suit). II., 564-5. **2255-9.**

SAWYER-MAN LAMP—(*Continued*):

I am unable to say how many lamps like that shown in Patent 205,144, we made before we left Centre Street. I think from fifteen to twenty-five separate and entire lamps, and perhaps a hundred separate and entire lamps, counting those in which the parts were used over. Of the lamps like that in Patent 210,809, I cannot say how many we made while at Centre Street (McKeesport suit). II., 581. **2322-3.**

Before our experiments with paper, we had made some lamps, which, considering their cheapness and practicability, would be useful to-day, if the present improved lamps could not be obtained, and in places where those lamps were not at hand for use (McKeesport suit). II., 592. **2366-7.**

The very first lamps made at Centre Street had Florence flasks for globes. They were intelligently planned for lamps, and their parts adapted for all the purposes of lamps. They were lighted up and run as lamps. Lamps, each perhaps an improvement in some particulars upon the other that had gone before it, were certainly made at Centre Street, until we reached lamps that were satisfactory to us for the time being (McKeesport suit). II., 597. **2385-7.**

In the first lamp run to incandescence at Centre Street, the incandescent conductor was a pencil of gas retort, or of French carbon; the glass was a Florence flask. The incandescent conductor was held between two metal supports in depressions made in the support by the pressure of the support against the ends of the conductor. I don't recollect who constructed the apparatus. It was put together in my presence, and Mr. Sawyer and myself bought the flasks. The base of the apparatus was of cast brass, one ring cemented to the Florence flask and the other screwed upon that, with an insulation through the base for one of the holders. One of the holders was simply screwed down into the base or cup on the inside; the other passed through a piece of hard rubber, screwed into the base, and thus insulated from it, terminating in a binding screw. The other binding screw was fastened to the outside of the base. There were orifices in the base, with stopcocks for passing the gas in and out of the lamp in charging it (McKeesport suit). II., 598-9. **2390-4.**

The first change that we made in our lamp made at Centre Street was in using, instead of the Florence flask, a straight glass tube, with a metal cap at either end; the conductors were screwed into the metal cap on the inside; the caps cemented to the tube, and the incandescent conductors extended from the end of one holder to the end of the other (McKeesport suit). II. 603. **2412.**

When we first lighted up our lamps at Centre Street, the carbons soon fell out of the holders. We discovered that the copper holder was fused where it touched the incandescent conductor. We therefore faced them with

SAWYER-MAN LAMP—(*Continued*):

platinum, which only melts at a high heat. We soon found that a deposit of carbon was being made upon the incandescent conductors, at first hard and dense, and as the deposit went on and the incandescent conductors increased in size, their resistance decreased, and the deposit became sooty and loose, and grew rapidly to such a size that the carbons were no longer luminous. We coupled them in series, in single multiple arc, and in multiple arc series, to see which was the best method of coupling with the current we were using (McKeesport suit). II., 634, **2493-4.**

When we filed the application for Patent No. 205,144 (May 16th, 1878), we considered that the lamp therein described contained the elements of a practical electric lamp (McKeesport suit). III., 635, **2537.**

Prior to filing the application for Patent 205,144, we had made lamps simpler and cheaper in construction, and not having the expensive and inferior feeder mechanism, but we thought if we did not cover the device of a feeder lamp by our patent, others would do so, and we thought it desirable to patent the feeding feature of a lamp (McKeesport suit). II., 646, **2581-3.**

In Patent 210,809, there was not a feeding device, nor one that would practically so act, because when the electrical connection between the incandescent carbon and its holders was not sufficiently good to prevent an arc being formed between the carbon and its holders, the practical life of the lamp was ended. There is nothing in the patent showing or stating that the incandescent carbon was rigidly attached to its holders, but such was the fact in practice, and such became the fact by use (McKeesport suit). II., 652-3, **2607-8.**

I *know* that at the time the applications were filed for Patents Nos. 205,144, and 210,809, they described operative mechanisms and practical lamps (McKeesport suit). II., 664-5, **2656-7.**

Patent No. 227,118, was applied for by me because it was my own invention, belonged to me, and I thought it was a simple way of avoiding tension, torsion or compression upon a straight pencil—things which I had before then discovered might be injurious, if excessive (McKeesport suit). II., 669, **2674.**

The lamps described in Patents Nos. 205,144, and 210,809, were not well adapted to the smallest carbons (McKeesport suit). II., 670, **2677.**

In the lamps described in Patent 205,144, we found it important to turn on the current gradually, because we were using a lamp filled with gas, and

SAWYER-MAN LAMP—(*Continued*):

because the carbon was suddenly broken when the current was turned on suddenly at full force (McKeesport suit). II., 679, **2713-4.**

At the conclusion of our experiments in March, 1879, or, rather, prior to that time, while we were still at Walker Street, the Electro-Dynamic Light Company considered our lamps so far perfected as to order several hundred to be made. (Note. The minutes of the meetings of the Electro-Dynamic Company only show one proposed order [March 20th, 1879], and that for twenty feeder lamps [*Garden*, V., 3269]. In this connection, it is well to bear in mind that a contract was soon afteward [June 10th, 1879] made with the Wallaces to manufacture the feeder lamp at Ansonia on a royalty.) There were two or three forms that we preferred—a straight pencil of carbon, the loop or arch-form carbon, and a carbon held straight across the tops of the holders, with adjustable tension between the holders. The reason that in filling this large order for lamps intended to be used commercially, carbons of different material were used, some of which we believed to be inferior, was due to Mr. Sawyer's being drunk, neglecting his work, and making bad work, &c., being capricious, unmanageable and incompetent to exercise good judgment, and to my inability to be present at the workshop. My preference at that time was for paper fiber or paper carbon treated to some extent. Some two hundred lamps were made, of which perhaps fifty had loop or arch shaped carbons, and from a third to a half had conductors of fibrous material (McKeesport suit). II., 771-81, **3083-3123.**

The two hundred lamps ordered were paid for by the Electro-Dynamic Company, and there are books and bills and papers that would show what was paid for part of it. (Note. The books of the Electro-Dynamic Company, in evidence, do not appear to give this information [Vol. II., 3296-7].) The lamps were delivered to the company and were its property (McKeesport suit). II., 785-6, **3139-41.**

The majority of the lamps made at Walker Street had straight carbons (McKeesport suit). II., 796, **3182.**

I should judge there were somewhere between two and three hundred lamps made at Walker Street. About two hundred and fifty or sixty would be the minimum idea in my mind of the number, and it may have been very much more than three hundred (McKeesport suit). II., 796, **3183-4.**

We hoped to make the lamps as cheaply as a quarter of a dollar apiece, but we never did build any so cheap as that nor anything near it that were permanent lamps (McKeesport suit). II., 805, **3219-20.**

The lamps made at present by the Consolidated Company are not similar in form or appearance to those made by Sawyer & Man, but they are similar in principle and involve the use of the same patents and inventions as devices, in whole or in part (McKeesport suit). II., 844, **3374.**

SAWYER-MAN LAMP—(*Continued*):

I cannot fix the number of lamps, certainly, set up and illuminated at Walker Street, between the 1st of October, 1878, and the 15th of March, 1879. It was a large number, in my judgment, exceeding one hundred, and, according to my recollection, as I look back upon it, running to between two and three hundred, but the manner of our work was such—lamps being used over and over again, and modified and changed in whole or in part as to their interior works—that I cannot be certain in regard to the matter. Whether lamps in use were new or modified, or refilled or refitted lamps, is a matter which confuses my recollection (McKeesport suit). II., 897, **3585-6.**

We were frequently and often changing the carbon holders and their adjustments with the carbon incandescing conductor. In the straight pencil lamps the method of holding them in the carbon clamps or holders was very frequently changed. Again, the parts of the lamp above the diaphragm (which diaphragm is represented, in the exhibits presented me to-day, by the glass support of the leading-in conductors) were frequently changed to use carbons for incandescent conductors of different shapes, or lengths, or sizes, such as the change from straight pencils to arch-shaped carbons of greater or less diameter, or the reverse, from arch-shaped to straight pencils of greater or less length. The occasion for doing this was to make a lamp which in all its parts, except the incandescent carbon conductor, would be permanent, and to make a lamp of such construction that a new incandescent conductor could be substituted in the lamp, which itself was permanent (McKeesport suit). II., 935-6, **3739-42.**

From the beginning of our work to its close there were two general classes of the lamps, straight pencils and arched pencils, or U or other shapes, in which latter the incandescent conductor rose above or extended beyond both the holders or conductors leading to it (McKeesport suit). II., 941, **3764.**

In the use of our lamp chambers, sometimes with nitrogen, sometimes with less of it, or in vacuum, we employed always the same internal apparatus, sometimes the same carbons, sometimes others. During the entire period of my union with Mr. Sawyer, our lamps were used over and over, modified from time to time (McKeesport suit). II., 957-8, **3828-9.**

Our long lamp adapted to the arch form of carbon could have been manufactured and sold, at a fair profit, at a dollar and a half to a dollar and seventy-five cents. The cost of the same type of lamp, but with straight pencil carbon, would be the same, or possibly seventy-five cents more. The lamp with the spiral conductors would cost from twenty-five to fifty cents more. The feeder lamp would cost $10 or $12, possibly $15, and the profit would have to be got on that (McKeesport suit). II., 959, **3833-4.**

SAWYER-MAN WORKSHOP:

At Centre Street we had two or three Arnoux & Hochhausen dynamos, one built especially for us, the others loaned us. We also had a Weston machine or two, possibly a Farmer-Wallace machine, or possibly some other manufacturer's. I cannot state just now how many machines we had in Centre Street in use or on trial (McKeesport suit). II., 486 and 490, **1943** and **1969.**

At Centre Street we had no separate engine, but depended on the power in the building (McKeesport suit). II., 491, **1961.**

At Centre Street we had dynamo machines, a lathe or two, a pretty good assortment of drills, files, chisels, dies, screw taps, hammers, saws, wrenches, and other bench tools, vices, laps, glass cutters, glass grinders, grindstones, whetstones, bits, bit-stocks. I don't recollect where they were bought. We had a great variety of apparatus, retorts, gas-holders, gas-bags, tubes and tubing in glass and metal, stop-cocks, oil and alcohol, kerosene lamps, gas-heating apparatus, gas-generating apparatus, electrical apparatus, photometer, air-pumps, one or more mercurial exhausting apparatus operated on the principle of Geissler's pump. There was a great variety of utensils or apparatus in glass, glass-mould boxes for carbonizing, means of drying, deoxidizing, and purifying gases. We had charcoal furnaces, urged by bellows, for heating apparatus. We had several gas heaters of different forms and kinds. Of gas generators, I remember we had several for producing hydrogen gas, several for producing nitrogen gas, several for producing carbonic acid gas, some for producing chlorine and several for producing cyanogen (McKeesport suit). II., 494-6, **1975-82.**

For furnaces at Centre Street we had: an ordinary furnace, like a tinner's or roofer's furnace; another one like an ordinary household furnace; another one was made long and divided into compartments, on which tubing running lengthwise was supported to prevent the tubing from bending when highly heated, similar to like apparatus sold by chemical dealers, but longer and larger; some others of the same kind, but of less size (McKeesport suit). II., 496, **1982-83.**

At Centre Street we had several galvanic batteries, some standard resistances, galvanometers, electric lamps, dynamos, thermo-electric battery, ordinary electroscopes; we had electro-magnets, electric coils, switches, cut-outs, two or three regular devices, all costing, I think, from $2,500 to $4,000. I cannot recollect from whom this apparatus was obtained (McKeesport suit). II., 497-8, **1986-92.**

Of the expenditures made at Centre Street no books, accounts, nor vouchers were kept. I don't know that any of the $2,500 to $4,000 expended there was paid by check (McKeesport suit). II., 499, **1994-5.**

The working force at Centre Street was Wm. E. Sawyer and myself; Mr. Wm. Sawyer, his father, part of the time; Mr. Sharp, part of the time,

SAWYER-MAN WORKSHOP—(*Continued*):

and part of the time at his shop in Brooklyn; Mr. Keating and one or two of his men, part of the time only; Geo. Sawyer, a boy who ran errands (McKeesport suit). II., 501, **2002.**

The occasion of leaving Centre Street (May or June, 1878) was that we had got our lamp and other inventions perfected and did not desire to go further until we secured our patents, and desired to avoid expense, while we did not need a workshop or laboratory (McKeesport suit). II., 501, **2003-4.**

I was at the workshop usually from 8 to 9 or 9:30 in the morning, and from 3:30 until dark (McKeesport suit). II., 502, **2006.**

I do not agree with Mr. Sawyer when he says that after we moved to No. 2 Howard Street we did not make any experiments on lamps, not having facilities for such experiments. We made a lot of experiments while we were at Howard Street and had as assistants Mr. Frank Holbrook and Mr. Edward Myers; we also had Messrs. Arnoux & Hochhausen, who were above us, doing a lot of work for us (McKeesport suit). II., 505, **2017-18.**

At Howard Street we had only one room, about 12 x 20, with shop facilities in another room, about 25 x 40 or 50, occupied mainly by Arnoux & Hochhausen. At Howard Street we had the same apparatus, tools and machinery as at Centre Street, a part being left, I think, at Centre Street until we wanted to use it. At Howard Street we had only the steam power of the building (McKeesport suit). II., 506-7, **2023-6.**

At Howard Street I do not remember any other than Hochhausen electric machines being used by us. These were made for electro-plating, but one or more were wound especially for us for incandescent lighting (McKeesport suit). II., 508, **2029-30.**

From the 1st of September until we left Howard Street we made experiments in making carbons, preparation of and treatment of carbons after their manufacture; in making and purifying nitrogen and other gases; experiments in resistances and switches: experiments in dividing the current and in distribution and measurement; experiments in filling the lamps and treating the carbon in process of filling; experiments in exhausting the lamps and lamps not exhausted; experiments in safety devices and cut-outs; experiments on globes of different sizes and forms, and generally getting ready to manufacture lamps upon a commercial scale and put them in use (McKeesport suit). II., 510, **2037-8.**

At Howard Street, the force was composed of Mr. Sawyer's father and Mr. Sharp, for workmen, Mr. George Sawyer, Mr. Wm. E. Sawyer, Mr. Frank Holbrook, and Mr. E. L. Meyers and myself. We had a large amount of work done outside by the firm of H. L. Judd & Co., Arnoux &

SAWYER-MAN WORKSHOP—(*Continued*):

Hochhausen, by Miller & Newman, and by various other people. Mr. Holbrook use to go to the School of Mines to use chemical apparatus, such as air-pumps, tubing, glass holders, retorts and stop-cocks. We had, I think, apparatus of this character at Howard Street, but Holbrook and Meyers thought that the apparatus at the colleges were better and more convenient than that which we had (McKeesport suit). II., 510-12, **2040-8.**

At Walker Street the working force was the elder Mr. Sawyer, E. L. Meyers and Mr. Sharp; they were there all the time. Machinists and instrument makers were hired from time to time, and Mr. Lawrence Meyers was there about a month. We had a very complete set of machinists's and instrument-makers' tools, a partial set of carpenters' tools, a miscellaneous lot of bench tools of all kinds for doing all sorts of things—working in wood, metals, stone and carbon. A pretty complete chemical laboratory, with pumps, retorts, furnaces, piping, tubing, stop-cocks, pinch-cocks and other chemical apparatus; two dynamos, two engine lathes, lathe tools and gearing, steam engine, pulleys, shafting and belting, electrical instruments, photometers, electrical testing and measuring apparatus, lamps, switches, resistances, electro-plating baths and apparatus, electric batteries, lenses, etc., etc. (McKeesport suit). II., 513-4, **2051-4.**

The experiments at Walker Street were for the purpose of perfecting and exhibiting a system of incandescent lighting with all its necessary accessories, and getting it ready to introduce in practical operation. The dynamos used by us there were one we bought while at Centre Street, one or two machines which we borrowed of Arnoux & Hochhausen for trial, and one large machine which we bought of them in September; which was specially wound for us. We could use these machines, but they were not specially adapted to our lamps—not so well as the machine made in September and the one mentioned in Exhibit "Dynamo Bill." Our engine was a six horse-power Hampton steam engine (McKeesport suit). II., 514-15, **2054-60.**

I cannot give the size of the wire on the armature of the machine that was wound for us, nor the resistance of the armature and field; nor can I say in what manner the circuits in the machine were connected up. I guess the electro-motive force was some twenty-five or thirty volts; it may have been much more or it may have been less. I don't think it was very much more than five volts, but I do swear at the same time I don't know anything about it. I think the machines we used would probably be estimated from thirty to two hundred volts (McKeesport suit). II., 532-534., **2127-35.**

Before going to Walker Street we had, and in part got delivered, the various parts necessary for making our lamps; had given orders for making of a dynamo, bought and prepared electrical apparatus, resistances and measuring instruments; our work was given to the preparation and test-

SAWYER-MAN WORKSHOP—(*Continued*):

ing of different kinds of carbons and their adaptability for use in different lamps as incandescent conductors; testing and trying different dynamos and different methods and extent of treatment of the incandescent carbon conductors; preparing switches, regulators, resistances and automatic cut-outs. After we got a sufficient number of lamps ready, they were exhibited to the officers of the company—the directors, stockholders and and friends. I have omitted to mention the very extensive work that was carried on at Centre Street, Howard Street and Walker Street in reference to the atmosphere of the lamps. This work involved extensive chemical apparatus and materials and means of exhausting the chamber of the lamp, and was carried on partly in our own shop, partly at the Stevens Institute, also at the School of Mines, and in a place on Broadway, near the Battery (McKeesport suit). II., 792 4, **3168-74.**

The main portion of the work was to be made outside; the setting up and assembling or putting together, such as making carbon conductors, was to be done in the shop (McKeesport suit). II., 830, **3319-20.**

We were all the time buying tools and having them made, of different kinds and a great variety of patterns and samples. It was a very large expense —thousands of dollars (McKeesport suit). II., 831-2, **3324-5.**

The money for special tools and apparatus was obtained by the sale of the stock (McKeesport suit). II., 833, **3330.**

The tools I bought from the Electro-Dynamic Light Co., such as they had in their shops, and such as I could find with the different manufacturers who had done work for the company, except the engine, some of the pulleys and shafting, and some general tools and one lathe, and perhaps some other things which were sold off to different people at the time when we closed the shop at 94 Walker Street. Part of them I still have; part of them I have sold, and part of them I lent to Mr. Sawyer and never got them back again. I think the major part is sold. I should think I realized from two or three to five hundred dollars from the sale (McKeesport suit). II., 837, **3345-8.**

Note. The minutes of the Electro-Dynamic Light Company (Vol. II., p. 3298) show that Mr. Man received $165 for the engine and $30.69 for the odds and ends of no further use to the company.

At Walker Street there was a hall seventeen feet six inches long by seven or eight feet wide; a front room seventeen feet six inches by eighteen feet six inches; a back room twenty-two feet six inches by nineteen feet, and an engine room seventeen feet by seven feet. At Centre Street the room was forty feet and five inches long and twenty-seven feet six inches wide. This room was divided by a partition into two rooms, the smaller being about twelve feet wide and twenty feet long (McKeesport suit). II., 889-91, **3553-61.**

SAWYER-MAN WORKSHOP—(*Continued*):

Very little manufacturing, except carbons and models and patterns, was done at 94 Walker Street. The several parts of lamps, excepting carbon conductors, were divided up and separate pieces were sent to different shops and mechanics to be manufactured and finished (McKeesport suit.) II., 891, **3563.**

SEALING:

In the Sawyer-Man horseshoe carbon lamp made in 1878, the glass part of the lamp consists of a tube like a large test tube with a flange at one end and the other end closed; what is called the base of the lamp consists of a round, flat disk of glass, through which the leading-in conductors pass. The inner parts of the lamp are set up upon this glass disk. The disk and flange are ground together after first being made very nearly true, until their junction seems as transparent as the rest of the glass. Tubular binding screws of metal pass through the glass disk, having a solid flange on their inside part; the flange is ground down to the disk by revolving the binding screw until the metal and disk fit perfectly air-tight. Outside of the disk a nut, threaded upon the bolt, is also fitted tightly to the glass. Between the flange and the glass, and the nut and the glass, are placed washers—sometimes of soft metallic foil and sometimes of thin paper; in either case the junctions being sometimes filled with Canada balsam and sometimes left with nothing. The nut on the outside was then screwed up tightly. In the tubes are stop-cocks outside of the nut, inserted in the bore of the tubes. The interior works, having been set up upon the base, were inserted in the tube. The base and outer end of the flange were varnished with a coat of Canada balsam, and the flange and base-plate fastened together and thoroughly clamped together by metal rings and screws; a cushion of paper or wood being interposed between the metal rings and the glass, to prevent fracture of the glass and allow of expansion and contraction by the elasticity of the wood or paper. The junction between the glass base-plate and the flange was then covered with a preparation of tempered sealing-wax. After the lamp was, as we called it, charged, the stop-cocks were turned and their ends and the nuts around the tubes were covered with solder. The ends of the tubes were then filled with solder and the lead of the lead tube which was in them. A spun-metal cap filled with sealing-wax, with a small orifice in the end, was then put over all, covering the tubular bolts and the glass next the ring, and the whole thing; electrical connection being made, however, between the tubular bolts and these covers. These caps were in some cases screw-threaded on to the bolts; the orifice in the caps was soldered up where any existed. The bottom plate between the rings and the bolts was then covered with melted sealing-wax. Over all, a spun-metal cap, covering all the base and coming up to the top of the rings, was placed, filled with melted beeswax or like substance. The lead pipes leading from the binding bolts were pinched together with pincers before being soldered off. II., 415-6, **1658-64.**

SEALING—(*Continued*):

The method of sealing practiced by us in 1878 was substantially pursued in making all the different types of lamp made by us down to the time Mr. Sawyer and I separated. II., 417, **1665.**

We experience no difficulty in the sealing of the lamp on account of the heat generated by the incandescent burner (McKeesport suit). II., 458, **1830.**

We experienced no difficulty in the sealing of our lamps from the effects of the heat generated by the lamp. We used the soapstone disk merely as a precaution. We subsequently ascertained that it was not necessary and ultimately left it out (McKeesport suit). II., 464, **1854-6.**

In the first lamp made at Centre Street the base of the apparatus was of cast brass, one ring cemented to the Florence flask and the other screwed upon that, with an insulation through the base of one of the holders. One of the holders was simply screwed down into the bottom of the base or cup on the inside; the other passed through a piece of hard rubber, screwed into the base and thus insulated from it, terminating in a binding screw. The other binding screw was fastened to the outside of the base. There were orifices in the base, with stop-cocks for passing the gas in and out of the lamp in charging it (McKeesport suit). II., 599, **2393-4.**

In our first lamp made at Centre Street we discovered in a day or two that the sealing was defective. Leaving them standing over night charged with illuminating or hydrogen gas, when the current was turned on the next day, one or more of the lamps exploded, showing that they had taken in atmospheric air, which formed the explosive mixture, causing the lamps to explode, showing that the lamps leaked. This necessitated frequent recharging. At this period we were endeavoring to get a better sealed lamp (McKeesport suit). II., 627, **2506-7.**

The object of trying the glass stoppers, instead of the metallic bases, was to obtain an apparatus that would better preserve the atmosphere of the lamp. It could be better sealed up, and better insulation of the wires from each other was obtained for the leading-in conductors (McKeesport suit). II., 629, **2516.**

The lamp described in Patent 205,144, should be tightly sealed, because the atmosphere within the lamps would be expanded by the heat of the incandescent conductor, and be forced out; when the lamp cooled, air from the outside would rush in (McKeesport suit). II., 670, **2679.**

SHAPING:

We made burners from a mixture of powdered carbon, with tar, glue, sugar, or other carbonizable material, which material in a damp powdered state, after being pressed and carbonized, was cut into the desired shapes,

SHAPING—(*Continued*):

straight pencils or arches, and then recarbonized, and all the conductors were finished by cementing to a lap, like a piece of plate glass or smooth metal, and working them down with files and fine emery paper. II., 407, **1627.**

The horseshoe form of carbon used in "Defendant's Exhibit Sawyer-Man Lamp for Horseshoe Carbon," was produced by cutting to shape and size and carbonizing in a closed chamber packed in powdered carbon. II., 412, **1646.**

In the spring of 1878 we at first carbonized the wood *en masse*, and sawed and cut straight pencils of carbon out of it, and also turned rings out of the charcoal on a lathe, by first turning up a cylinder, boring it to make a tube, and then cutting a ring off the end of the tube so formed. Afterward we adopted the plan of cutting the wood substantially to the size and form of the carbon we desired, and bent it to shape and then carbonized it. Some of the wood that we used, such as excelsior, was already in fine strings, and only required to be smoothed up, softened and bent before carbonization. Some of the wood was in the form of veneers, cut extremely thin in sheets, from which we cut out the shapes we wanted, and then smoothed them up and carbonized them. The forms were straight pencils, loops and arches. At first we carbonized paper in sheets; sometimes several sheets stuck together and pressed, from which, after carbonization, we cut out pencils and arches. After making a few carbons in this way, we cut out of the paper before carbonization various forms—straight pencils with enlarged ends, straight-pencils with pointed ends, arches and loops, some of the arches having angular forms in them, some of them waving forms, some of them small crosses and stars in their length. They were then packed in crucibles in powered carbon or plumbago, or both, and carbonized. We frequently worked the carbons down and smoothed them off after taking them from the box. The ends of paper and wood carbons in the looped and arched forms were usually enlarged where they were attached to the conductors, but not always. In some of the wood carbons that we made of thin veneers, I think rose-wood and mahogany, we worked the wood down into extremely thin tenuous sheets on a lap, or on fine emery paper cemented to a lap and put several sheets together, in some instances with glue and in some with sugar, so that the fiber of the wood would run in different directions, and after they were dried, would cut pieces for carbonization of all kinds and shapes from them (McKeesport suit). II., 438-9, **1749-56.**

At first we kept the carbons in shape with very fine wire wherever they were bent. Where they were cut into shapes of loops or arches they did not require tying. When they were bent in they required fastening; sometimes they were fastened by being pressed with the powdered carbon. Subsequently, in the fall of 1878, we got a block of carbon and bent them over that and fastened them to the block with clamps, and carbonized them in that way (McKeesport suit). II., 442, **1767-8.**

SHAPING—(*Continued*):

We generally reduced our carbons to size and shape before carbonization, because the material was more easily worked than afterwards. We selected paper because it was already reduced to size in one direction, and its fibers were nearly all in one plane. We cut the wood so as to have the fibers run in the direction of length of the conductor.

(Note. Mr. Man says (Vol. II., 439): "In some of the wood carbons that we made of thin veneers we worked the wood, &c., * * * and put several sheets together, * * * so that the fiber of the wood would run in different directions," &c.)

By these means we were able to get a pure carbon without flaws or cracks, by which we were troubled in endeavoring to carbonize in mass and afterwards reduce to size and shape, and also because the carbonization of the small incandescent conductors was more perfect and uniform where they were cut to size and shape before carbonization than could be made from substances in mass. We decided that it was too expensive and unsatisfactory to work them down after carbonization (McKeesport suit). II., 463-4, **1849-1853.**

Prior to trying paper we had been making conductors out of French carbons in straight pencils, working down the pencils to get them small; we had also been making carbons out of thin sheets of French carbon, which we formed into an arch to rise above the holders of the lamps; we had great difficulty in working down these carbons to size and shape such as we were then trying to use. We saw in the use of paper a means that would avoid the difficult operation of shaping carbons and sizing them, by shaping and sizing the material from which they were made (McKeesport suit). II., 591-2, **2362-5.**

The pencils of French carbon used in our first lamps at Centre Street were already of the desired diameter, and only required to be cut off to the length we wished to use; the ends were cut and smoothed off (McKeesport suit). II., 622, **2487-8.**

The carbons in our tulip-shaped lamps were mostly small circular rings or loops of carbonized wood and paper, cut to size and shape before carbonization (McKeesport suit). II., 928, **3712.**

VACUUM:

We heated up the outside of the lamp while the exhaustion was going on, and turned on a current of electricity and heated the carbon burner to high incandescence; the other parts of the lamp were also heated by this passage of the current to some extent. After allowing the lamp to stand with an exhausted atmosphere for some time, we repeated these operations after again washing the lamp out with pure nitrogen, the object being to carry these impurities out of the lamp. II., 417, **1666-7.**

VACUUM—(*Continued*):

We fitted the parts of the lamp together accurately, so that a vacuum would be well maintained in the lamp with nothing further done. We then placed Canada balsam upon the glass, and firmly clamped the pieces together and covered the junction with melted wax, or other substance, to exclude all air from it. In this way we succeeded in getting an enclosing chamber in which we could maintain a high vacuum for an indefinite time (McKeesport suit). II., 457-8, **1828-30.**

In our second style of lamp, made at Centre Street, I think we tried a vacuum, but am not positive (McKeesport suit). II., 605, **2417.**

We did not endeavor to preserve a vacuum in lamps made according to Patent 205,144, at Centre Street (McKeesport suit). II., 678, **2717.**

Note. On page 458 of Vol. II., Mr. Man testifies that at Centre Street they got an enclosing chamber in which they could maintain a high vacuum for an indefinite time.

In the lamps described in Patent 205,144, we found it important to turn on the current gradually, because we were using a lamp filled with gas, and because the carbon was suddenly broken when the current was turned on suddenly at full force (McKeesport suit). II., 679, **2713-4.**

At Centre Street, as a means of supporting a vacuum, we had an air pump worked by hand, and also used an exhausting apparatus with mercury. It was of the character of a Geissler pump, operating by displacement of air by mercury; we put it up ourselves (McKeesport suit). II., 750-1, **2997-3001.**

Note. Sharp, in his Statement, Vol. II., 3416, testifies that he never saw nor knew of any apparatus of this description, except a water suction apparatus. Stillman testifies, Vol. II., p. 1111, that the apparatus for exhaustion was a simple water exhaust. Geo. W. Sawyer, Vol. II., 3317, testifies to their using the fall of water from the roof to secure the vacuum.

We tried all extents of vacuum, from slightly below atmospheric pressure, perhaps a third of the pressure removed, up to the highest we could get; we had difficulty in preserving the higher vacuum, and we adopted ordinarily in practice, therefore, a lower vacuum than the highest we could get, as an ordinary thing (McKeesport suit). II., 755, **3017.**

The Consolidated Company use in their lamps an inert or exhausted atmosphere, which terms I consider synonymous (McKeesport suit). II., 843, **3370-2.**

With our water exhaust at Walker Street we got an exhaustion sometimes more and sometimes less, according to the flow of water in the Croton

MAN, Albon.

VACUUM—(*Continued*):

water system. When the flow was good we could obtain by it an exhaust whose pressure was substantially equal to the tension of water vapor at ordinary normal temperature of the atmosphere, or about that. It was such an exhaust that the height of the mercury in the gauge which measured it could hardly be distinguished from the height of the mercury in the barometer standing beside the mercury gauge (McKeesport suit). II., 919, **3675-6.**

Crookes, in one of his experiments, published prior to 1878, shows a lamp in which a platinum incandescent burner is used in vacuo. I think King, in his patents and descriptions, also gives an account of such a lamp (McKeesport suit). II., 955, **3819.**

I think the vacuum obtained by Crookes was a very perfect one. That obtained by Sawyer & Man was not so perfect, as a vacuum, as that obtained by Crookes, though it was in some cases very perfect. The vacuum obtained by the others (that is, prior inventors) I suppose was less perfect than that obtained by Sawyer & Man. The principle of the Crookes's vacuum and that of Sawyer & Man was the same. All of our lamps, substantially, had a more or less perfect vacuum in them, varying from an internal pressure, as I estimate, of two-thirds of an atmosphere to a very perfect exhaustion or vacuum (McKeesport suit). II., 956-7, **3823-6.**

MAXWELL, Prof. James Clerk.

GEISSLER TUBES:

Experiments do not show any conduction of electricity through air, or even through mercury vapor. "It is probable that if we could support an electrified body on a perfectly insulating stand, so that it could lose its charge only by conduction through the air, it would never lose its charge." "If the electro-motive force acting at any point of a dielectric is gradually increased, a limit is at length reached at which there is a sudden electrical discharge through the dielectric, generally accompanied with light and sound. * * * Thus electro-motive force and electric displacement correspond to ordinary force and ordinary displacement; the electro-motive force which produces disruptive discharge corresponds to the breaking stress. Conduction or the transmission of electricity correspond to permanent bending." "The electro-motive force necessary to produce the discharge diminishes, while the pressure is reduced from that of the atmosphere to that of about three millimetres of mercury" ("Elementary Electricity," 1881). VI., 4389-92.

MORTON, Dr. Henry.

AMPERE:

Meaning of term explained. III., 1237, **4947.**

ART, HISTORY OF:

prior to Sawyer-Man patent, does not show a lamp structure like or equivalent to theirs (McKeesport suit). III., 1337, **5346.** Note: The lamp chamber referred to consists substantially of a glass globe and a separable glass base with ground glass joint. The leading wires pass through and are cemented into the glass base.

BURNER OF CARBON:

Concerning the description of Edison's carbon lamp, which appeared in the "New York Herald," Prof. Morton says that it will be a conspicuous failure, and does not recognize in it anything different from the "* * * old method repeatedly tried and abandoned by others * * *" (Letter of December 22, 1879, to the "Sanitary Engineer"). VI., 4164.

If instructed to make a carbon burner from vegetable fibrous or textile material, a skilled person would naturally make use of cotton or linen thread or split canes, bamboos and the like (McKeesport suit). III., 1294, **5176.**

If instructed to make a carbon burner from paper, a skilled person would naturally select a pure paper made from vegetable fibre and of uniform thickness (McKeesport suit). III., 1295, **5179-80.**

Konn's English Patent No. 3809, of 1872, suggests use of graphite only (McKeesport suit). III., 1319, **5273.**

Bink's English Patent No. 119, of 1853, refers only to process of making arc light carbons. This fact should dispose of it as having no relation to making of burners for incandescent lights (McKeesport suit). III., 1320, **5278.**

Sidot's process of making carbon relates to the transformation of vegetable fibre or textile material into coke. The utility of such material in replacing arc light pencils, usually made from gas carbon, is set forth by Sidot. He does not suggest its use for incandescent burners, and therefore does not anticipate the use of carbon made from such material, in the arch form, as an incandescent burner (McKeesport suit). III., 1322, **5288.**

BURNER OF CARBON—(*Continued*):

Violette incidentally remarks that charcoal made by his process serves better for arc lighting than gas carbon, but makes no suggestion of its applicability to burners of incandescent lamps, and therefore does not anticipate the use of carbon made from fibrous or textile material, in the arch form, as an incandescent burner (McKeesport suit). III., 1323, **5290.**

In the light of present knowledge we know that, to produce such an incandescent lamp as has proved itself to be commercially successful, fibrous vegetable material possesses special advantages, which are: first, facility for shaping before carbonization; second, ease with which uniformity in strength and resistance are obtained by the subsequent hydro-carbon treatment; third, high specific resistance; fourth, mechanical strength and elasticity; fifth, ease with which an initially uniform resistance can be obtained, such uniformity being due to equality of structure, cross-section and purity of the material (McKeesport suit). III., 1325-6, **5298-301.**

State of art prior to 1880 would have led one away from thought of making an incandescent burner out of carbonized fibrous or textile material, and to adopt a hard carbon, such as gas coke, as being the best material to use (McKeesport suit). III., 1329, **5314.**

of modern lamps, if straight, would be very liable to break, because in expanding it would be liable to bend at one point, and on shrinking would be subjected to a tensional strain. This liability to fracture was recognized prior to 1880, and some inventors attempted to overcome it by making use of yielding supports at the ends of the burner. (McKeesport suit). III., 1333-4, **5332-3.**

Since 1880 the carbons used in incandescent lamps have had the arch form or some modification of it. Straight carbons have not been used (McKeesport suit). III., 1334, **5334.**

A burner of hard carbon being brittle, would be likely to break from strains produced by expansion and contraction when in the arch form or when straight, although the arch form would overcome this difficulty to some extent (McKeesport suit). III., 1343-4, **5371-6.**

Hydro-carbon treatment is not applied by Edison in manufacture of burners. The United States Company only apply it to a portion of their burners (McKeesport suit). III., 1345, **5380.**

At date of King's patent little or nothing was known as to art of making carbon burners. III., 1349, **5393.**

Prior to 1879 the art of making carbon burners had not reached the development required for the complete practical commercial success of an electric lighting system. III., 1350, **5397.**

BURNER OF CARBON—(*Continued*):

Even if the state of the art of electric lighting, as it existed prior to 1879, had been developed to such an extent that by using the improved Carré carbons, or, better yet, the fibrous or textile material carbons of Sawyer & Man (subjected to the hydro-carbon treatment and electrical heating to remove occluded gases), individual lamps could be made which would operate efficiently and with considerable endurance, yet it would not have been possible to manufacture them with sufficient economy and uniformity, or to so use them as to render them of general commercial value. III., 1350, **5399.**

CANDLE-POWER:

A burner of large mass and radiating surface, if heated to economical incandescense, would result in development of a light of many hundred candle-power. A small mass and surface are demanded in order that a lamp may replace a source of light of moderate intensity like a gas burner or domestic lamp. III., 1231, **4923.**

CARBON:

Roberts's patent instructed the art to use gas-coke or similar resisting material and that use of wood charcoal, or like vegetable product, would depart radically from instructions of the patent (McKeesport suit). III., 1271, **5084.**

A special advantage of carbon from fibrous vegetable material is that it lends itself readily to the hydro-carbon treatment, whereby mechanical strength and uniformity of resistance are obtained (McKeesport suit). III., 1273, **5089.**

from fibrous or textile material would be "peculiarly *unfit*" for arc or semi-incandescent lamp pencils, because their specific resistance should be as low as possible. They would be ideally perfect, if with no resistance (McKeesport suit). III., 1273, **5092.**

for arc lights is not required to have that uniformity in resistance which is called for in the carbon of incandescent burners (McKeesport suit). III., 1274, **5094.**

Pure carbon in the condition of lampblack or other preparations can be so treated in the manufacture of arc light carbons as to produce a product quite as pure as that obtained from vegetable fibre (McKeesport suit). III., 1274, **5095**; also 1327, **5306.**

of burners of lamps in commercial use is same in series lamps of low resistance as in multiple arc lamps of high resistance, and is made from fibrous or textile materials (McKeesport suit). III., 1276, **5103**; also 1336, **5344.**

CARBON—(*Continued*):

from fibrous vegetable material possesses mechanical strength, enabling it to resist shocks and strains. This strength is combined with elasticity, which is particularly developed and utilized when burner has arch form (McKeesport suit). III., 4273, **5090.**

Sidot's process of making carbon relates to the transformation of vegetable fibre or textile material into coke. The utility of such material in replacing arc light pencils, usually made from gas carbon, is set forth by Sidot. He does not suggest its use for incandescent burners, and therefore does not anticipate the use of carbon made from such material, in the arch form, as an incandescent burner (McKeesport suit). III., 1322, **5288.**

Violette incidentally remarks that charcoal made by his process serves better for arc lighting than gas carbon, but makes no suggestion of its applicability to burners of incandescent lamps, and therefore does not anticipate the use of carbon made from fibrous or textile material, in the arch form, as an incandescent burner (McKeesport suit). III., 1323, **5290.**

for arc and semi-incandescent lighting should have the quality of hardness or extreme density in order to resist combustion. The object should be to secure a material of low specific and of high chemical resistance. A carbon made from fibrous or textile material would answer the purpose very badly, because of the rapid combustion which would take place. This was the reason for its early abandonment and the substitution of hard carbon in its place (McKeesport suit). III., 1327-8, **5308-11.**

It was known in 1852 (date of Robert's patent) that graphite possessed a greater resistance to combustion than any other form of carbon excepting the diamond (McKeesport suit). III., 1328, **5312**; also 1311, **5244.**

Arc lighting could not be carried on commercially, if carbon made from fibrous or textile material were used, because of its high specific resistance and low resistance to combustion (McKeesport suit). III., 1328-9, **5312-3.**

State of art prior to 1880 would have led one away from thought of making an incandescent burner out of carbonized fibrous or textile material, and to adopt a hard carbon, such as gas coke, as being the best material to use (McKeesport suit). III., 1329, **5314.**

made by Gauduin's process would be hard carbon, and would have none of the properties which characterize a carbon made from vegetable fibrous or textile material (McKeesport suit). III., 1343, **5340.**

CARBONIZATION:

Special instructions as to method of carbonization to be followed in carbonizing fibrous vegetable or textile material, shaped beforehand into the form of the burner, are entirely unnecessary (McKeesport suit). III., 1299, **5193-4.**

CLAMPS:

The liability of carbon burners to fracture by their expansion and contraction was recognized prior to 1880, and some inventors attempted to overcome it by making use of yielding supports at the ends of the burner (McKeesport suit). III., 1333-4, **5332-3.**

COMMERCIAL SUCCESS:

After referring to Jobart's account of De Changy's platinum lamp, to Edison's experiments in the same direction, and to Farmer's use of platinum lamps in 1859, the lecturer says: "It is true that nineteen years have not sufficed to render this admirable arrangement successful in practice, but what is that to the prophetic mind which, foreseeing what is to happen in the 'near future,' naturally overleaps distinctions between past and future, theory and practice." After referring to Edison's early platinum lamp with a current regulator to prevent the melting of the burner, the lecturer says: "True, this achievement was claimed for M. De Changy, and seems to be implied in Mr. Farmer's description; but somehow, as with the famous perpetual motion machine, 'the little screw which makes it all go' does not appear to have been forthcoming in either case; and in this present year of 1878 we still look to the 'future,' 'near' or remote, for the 'practical success' so confidently announced nineteen or twenty years ago." In speaking of the Sawyer-Man lamp, he states that "another modification of the Starr or Konn lamp is found in that which has been recently exhibited in New York as the Sawyer-Man lamp. * * * It is certain that none of these lamps have yet demonstrated anything like such practical success as can enable us to see that they can take the place of gas in ordinary illumination. They have, of course, many advantages in certain respects over the electric arc, but these are combined with compensating drawbacks on the part of economy; and it is only by turning our eyes to the as yet *unrevealed possibilities of the future* that we are able to see the electric light as *a successful substitute for gas and other methods of illumination*" (Lecture of Oct. 17, 1878). VI., 4069-70.

"Heretofore electric lights have only been practically developed in their concentrated form * * *" (Lecture of October 17, 1878). VI., 4083.

In his report to the Lighthouse Board, after reciting Jobart's article on de Changy's platinum lamp, and calling attention to an early platinum lamp of Farmer, Prof. Morton says: "Notwithstanding this very promising beginning, however, little or no progress seems to have been made in this (meaning incandescent) method of lighting for the twenty years intervening between the dates above given and the present time, for we

COMMERCIAL SUCCESS—(*Continued*):

certainly have no system of electric lighting by incandescence superior to that above described; nor has the older one or any of its newer rivals come into any general use. * * * Though none of them have proved practically useful as yet, nevertheless some notice of methods of lighting by incandescence should be here given historically for future reference" (Report of November 29, 1879, to Lighthouse Board). VI., 4134-5.

One of the chief difficulties in the way of the success of Edison's light (referring to the carbon lamp described in the "New York Herald") "* * * is the production of a lamp which shall be thoroughly reliable, and neither complicated nor expensive. All attempts up to the present lamp in this direction are acknowledged to be failures, and, as I have pointed out, there does not seem to be any novelty such as would authorize us to hope for a better success in the present one" (Interview published in "New York Times" of Dec. 28, 1879). VI., 4167.

In his account of incandescent lamps, in the "Scribner Magazine" article on "Electricity in Lighting," Dr. Morton says that a lamp with an incandescent burner was early considered to offer the most promise for general domestic lighting. He refers to the serious difficulty met with in the use of the early lamps having metallic burners, in that they were destroyed by melting of the burner, and says that an apparent escape from this difficulty by the use of hard carbon, such as arc light carbon, was met by another trouble, namely, that it was consumed by the oxygen of the air. To overcome this difficulty the carbon was protected from the air by enclosing it in a non-active gas or in a vacuum. The King lamp is then described, concerning which Dr. Morton says: "Though this lamp produced a brilliant light, it proved in various respects unsatisfactory, and was abandoned after numerous trials." The author then continues: "Other inventors, as, for example, Konn, of St. Petersburg, continued to work with rods or pencils of hard carbon, and achieved a limited success, but the irregularity and brittleness of the material seem to have been an insuperable objection and drawback, and the problem of commercial electric lighting by incandescent conductors yet remained without a solution." After saying that this state of affairs continued up to the fall of 1878, Dr. Morton ascribes the success of incandescent lighting to the Sawyer-Man invention of an arch-shaped fibrous or textile carbon burner, described in Patent No. 317,676. He says, however, that "The lamp brought out by Messrs. Sawyer & Man soon after their application of a patent, and described and shown in that application, was a rather large and complicated structure; and had no improvement and simplification of this structure been made, the present immense development in electric lighting would no doubt have been unattained. It is to Mr. T. A. Edison, without doubt, that we owe many of the simplifications and modifications which, by cheapening the lamp and diminishing its weight, have extended its range of use and its usefulness to a remarkable degree" (Article in "Scribner's Magazine" for Aug., 1889). VI., 4360-1.

NOTE. This patent was the subject of litigation in the McKeesport suit.

COMMERCIAL SUCCESS—(*Continued*):

In the light of our present knowledge we know that, to produce such an incandescent lamp as has proved itself to be commercially successful, fibrous vegetable material possesses special advantages, which are: first, facility for shaping before carbonization; second, ease with which uniformity in strength and resistance are obtained by the subsequent hydro-carbon treatment; third, high specific resistance; fourth, mechanical strength and elasticity; fifth, ease with which an initially uniform resistance can be obtained, such uniformity being due to equality of structure, cross-section, and purity of the material (McKeesport suit). III., 1295-6, **5298-301.**

Arc lighting could not be carried on commercially if carbon made from fibrous or textile material were used, because of its high specific resistance and low resistance to combustion (McKeesport suit). III., 1288-9, **5312-3.**

Prior to 1879 the art of making carbon burners had not reached the development required for the complete practical commercial success of an electric lighting system. III., 1350, **5397.**

Even if the state of the art of electric lighting, as it existed prior to 1879, had been developed to such an extent that, by using the improved Carré carbons, or, better yet, the fibrous or textile material carbons of Sawyer & Man (subjected to the hydro-carbon treatment and electrical heating to remove occluded gases), individual lamps could be made which would operate efficiently and with considerable endurance, yet it would not have been possible to manufacture them with sufficient economy and uniformity, or to so use them as to render them of general commercial value. III., 1350, **5399.**

CROOKES'S RADIOMETER:

"Several of the instruments produced by Dr. Crookes in the course of his researches were, in fact, incandescent lamps, consisting of platinum wires enclosed in glass vessels exhausted to a very high degree, the coils being heated to brilliant luminosity by electric currents" (Article in "Scribner's Magazine" for August, 1889). VI., 4364.

CROSS-SECTION:

Burner of incandescent lamp must have small cross-section in proportion to its length to obtain sufficient resistance, together with small mass and radiating surface, so that it will be intensely heated with minimum amount of heat. III., 1230, **4920.**

Resistance of filament of Edison's lamp is high, partly because it is made of carbon, but more to the fact that it is very thin and a very fine thread and filament (Canadian suit). III., 1279, **5114.**

CURRENT:

Manner in which it divides itself among "derived (multiple arc) circuits" explained. III., 1240-1, **4958-64.**

DISCOVERY:

Speaking of radiometers, Dr. Morton says: "Indeed, as was subsequently made apparent, the wonderful results obtained by Dr. Crookes in the production of very perfect vacua were of essential importance to the development of the incandescent electric lamp" (Article in "Scribner's Magazine" for August, 1889). VI., 4364.

DISTRIBUTION OF ELECTRICITY:

The general principles involved in methods of distribution were established and well known prior to 1879. III., 1350, **5398.**

DURABILITY:

After stating that the first incandescent lamp was invented by Starr, for which a patent was granted to his agent King, in 1845, and that it had been modified until it assumed the form known as the Konn lamp, the lecturer says, of the latter lamp, that "various modifications of this lamp have been made and elaborately experimented with; but they all show the same essential characteristics. The first of these is that, as long as any oxygen remains in the vessel, the carbon rods consume rapidly, the first one generally lasting only twenty minutes. The second carbon will, however, last two hours, if the light does not exceed forty burners; but even when all active gas has been removed, the carbon suffers a sort of vaporization. * * * Another modification of this Star or Konn lamp is found in that which has been recently exhibited in New York as the Sawyer-Man lamp. This differs from the former apparatus in no important feature except that the interior of the vessel is said to be filled with pure nitrogen at the ordinary pressure. The carbon rods are said not to waste away in these lamps. Without knowing anything positively on the subject, my opinion is that this is only because they have not been subjected to strong currents, but have only been heated to the extent of yielding the light of one or two burners. Under these circumstances, the carbons of the Konn lamp will last a long time, but, on the other hand, the light so obtained is not economical, as we see above" (Lecture of Oct. 17, 1878). VI., 4069-70.

"Lamps in all essential respects like these described by Mr. Edison have been in constant experimental use for several years past with one invariable result, namely, that while the carbon would operate from a few hours to several days, it has been found utterly impossible to render them reliably permanent" (Interview published in "New York Times" of December 28, 1879). VI., 4166.

DYNAMOS:

"Improvements in electro-motors (that is, machines for producing electricity, of which we shall speak further on) have given us relatively cheap electricity, obtainable with convenience wherever steam power is at hand" (Lecture of Oct. 17, 1878). VI., 4069. Note: The description of the electrical machines referred to is contained on pp. 4073 to 4081.

ECONOMY:

After referring to the de Changy and Farmer platinum lamps, Prof. Morton says: * * * "We certainly have no system of electric lighting by incandescence superior to that above described; nor has the older one or any of its newer rivals come into any general use. * * * The difficulties presented in the problem of producing light by incandescence were: 1. Its wastefulness of the energy employed, and consequent costliness; 2. The difficulty caused by the disintegration of the substance heated." Here follows a statement of the light which can be obtained from a platinum burner as compared with that from an arc light (Report of November 29, 1879, to Lighthouse Board). VI., 4134-7.

Tests made by Prof. Morton on one of the early Edison lamps, with "horse-shoe" carbon, gave 12 lamps of 10 candle-power each, or a total of 120 candles of light per horse-power. Prof. Morton says: "We have, then, the twelve Edison lamps, producing 120 candles, and the five gas burners, producing 100 to 110 candles, with an equivalent expenditure of fuel." Two later tests of the lamp gave respectively 112 and 120 candles of light (Tests, published in "Telegraphic Journal" for May 1 and 15, 1880). VI., 4240-3.

Meaning of terms "economy" and "efficiency" explained. III., 1239, **4954.**

As to costliness of electricity, very great improvements had been made prior to 1879 by the inventions of Gramme, Siemens, Weston, Brush and others (referring to dynamo machines), although room was left for considerable improvements since effected. III., 1349, **5396.**

ELASTICITY:

Carbon from fibrous vegetable material is elastic (McKeesport suit). III., 1273, **5090.**

ELECTRO-MOTIVE FORCE:

Its function in producing a current explained. III., 1229, **4915.**

The unit of electro-motive force is a "volt." One cell of Daniells' battery has an electro-motive force, or exerts a pressure of about one volt. III., 1237, **4945.**

EVAPORATION:

After stating that the first incandescent lamp was invented by Starr, for which a patent was granted to his agent King, in 1845, and that it had been modified until it assumed the form known as the Konn lamp, the lecturer says, of the latter lamp, that, "various modifications of this lamp have been made and elaborately experimented with; but they all show the same essential characteristics. The first of these is that, as long as any oxygen remains in the vessel, the carbon rods consume rapidly, the first one generally lasting only twenty minutes. The second carbon will, however, last two hours, if the light does not exceed forty burners; but even when all active gas has been removed, the carbon suffers a sort of vaporization. * * * Another modification of this Starr or Konn lamp is found in that which has been recently exhibited in New York as the Sawyer-Man lamp. This differs from the former apparatu in no important feature except that the interior of the vessel is said to be filled with pure nitrogen at the ordinary pressure. The carbon rods are said not to waste away in these lamps. Without knowing anything positively on the subject, my opinion is that this is only because they have not been subjected to strong currents, but have only been heated to the extent of yielding the light of one or two burners. Under these circumstances, the carbons of the Konn lamp will last a long time, but, on the other hand, the light so obtained is not economical, as we see above" (Lecture of Oct. 17, 1878). VI., 4069-70.

After referring to the De Changy and Farmer platinum lamps, and stating that "* * * we certainly have no system of electric lighting by incandescence superior to that above described, nor has the older one or any of its newer rivals come into any general use." Prof. Morton states that "the difficulties presented in the problem of producing light by incandescence were: 1. Its wastefulness of the energy employed and consequent costliness. 2. The difficulty caused by the disintegration of the substance heated." He states that platinum becomes brittle and finally breaks, and that "small rods of carbon placed in exhausted tubes admitted of higher temperatures, but were quite rapidly consumed, or, rather, vaporized and disintegrated." In speaking of the Konn lamp, which he states to be a modification of the King lamp, Prof. Morton says: "Various slight modifications of this (Konn) lamp have been made and elaborately experimented with; but they all show the same essential characteristics. The first is that, as long as any oxygen remains in the vessel, the carbon rods consume rapidly, the first one generally lasting only twenty minutes. The second carbon will, however, last two hours if the light does not exceed forty burners; but even when all active gas has been removed, the carbon suffers a sort of vaporization." In speaking of the Sawyer-Man lamp as a modification of the Starr or Konn lamp, he doubts whether the carbon burner will not also waste away if brought up to economical incandescence (Report of November 29, 1879, to Light-house Board). VI., 4134-7.

FILAMENT:

The word "filament" in first claim of Edison's Canadian patent "implies that it is a fibre or thread" (Canadian suit). III., 1277, **5108.**

FILAMENT OF CARBON:

of first claim of Edison's Canadian patent "must be of carbon of high resistance" (Canadian suit). III., 1277, **5108.**

of Edison's lamp is of high resistance, partly because it is made of carbon, but more to the fact that it is very thin and a very fine thread and filament (Canadian suit). III., 1279, **5114.**

The main feature of the invention and process described in Edison's Canadian patent, which, according to statement of said patent, reversed prior practice, is the carbon filament. Aside from the fact of the use of this carbon filament of high resistance, the other items (meaning certain statements made in the patent which are set out in the question) were old (Canadian suit). III., 1280, **5117.**

Edison's invention (referring to his Canadian patent), as far as the filament is concerned, is the production of a filament of carbon. This is placed in a globe of some kind capable of being exhausted of air (Canadian suit). III., 1280, **5120.**

FIRST CLAIM OF PATENT IN SUIT:

First claim of Edison's Canadian patent "clearly covers any form of incandescent electric lamp having in it a filament made of carbon and having a high resistance. The word filament implies that it is a fibre or thread. It must be of carbon, of high resistance and must be connected by conducting wires. Those are the essential features, and any lamp which included those features manifestly comes under that claim. Of course it involves with it some enclosure, since such a filament could not be used in the open air. That enclosure might be of the most varied character, so far as this claim is concerned, and the conditions under which they might be used. As long as these things are present the invention would be represented" (Canadian suit). III., 1277-8, **5108-9.**

GEISSLER TUBES:

In his lecture on the electric light, in speaking of electric light from incandescent gas, Prof. Morton says that "If the cross-section of the vessel is smaller the light is brighter, and thus, by the use of tubes with wire let into them, very brilliant effects can be produced. Such tubes are called, from their first manufacturer, a glass blower of Bonn, Geissler tubes, and some of the ordinary forms are shown in Fig. 8. By using different gases, and employing various fluorescent substances in the surrounding jackets, very beautiful combinations of colored lights are obtained." Nothing is said in his lecture about the use of such tubes in any way for illumination purposes, or that they can be so used (Lecture of October 17, 1878). VI., 4071.

GEISSLER TUBES—(*Continued*):

Speaking of Edison's early carbon "horseshoe" lamp, Dr. Morton says: "In this lamp the carbon conductor is supported on platinum wires and held in minute platinum clamps at the ends of these wires, which are sealed through the walls of the pear-shaped enclosing tube in the manner which had been familiar for twenty years in the construction of the beautiful electric toys known as 'Geissler tubes.' The author nowhere refers to Geissler tubes as being electric lamps or of their having been used as such (Article in "Scribner's Magazine" for August, 1889). VI., 4364.

HEATING DURING EXHAUSTION:

The process of driving occluded gases out of carbon burners has been universally employed since 1880. Without this process, or that of hydro-carbon treatment, lamps could not compete with those subjected to these processes (McKeesport suit). III., 1308, **5232.**

The high vacuum obtainable with Sprengel and Geissler pumps would not be adequately preserved unless heating during exhaustion, first applied to burners in 1878, were resorted to. III., 1348 **5392.**

HYDRO-CARBON TREATMENT:

A special advantage of carbon from fibrous vegetable material is that it lends itself readily to the hydro-carbon treatment, whereby mechanical strength and uniformity of resistance are obtained (McKeesport suit). III., 1273, **5089.**

Without the hydro-carbon treatment, or process of driving occluded gases out of the burner, lamps would not compete with those having burners which had been subjected to these processes.

The hydro-carbon treatment widens the range of materials from which burners may be made (McKeesport suit). III., 1309, **5233.**

is not applied in manufacture of lamps by Edison. The United States Company only apply it to a portion of their lamps (McKeesport suit). III., 1345, **5380.**

INVENTION INVOLVED:

in placing a carbon burner made from carbonized, fibrous or textile material in an hermetically sealed lamp chamber made wholly of glass (separable glass base) from which all carbon-consuming gases have been expelled, and in having leading wires pass through and hermetically sealed (cemented) into the glass, as described and claimed by Sawyer & Man (McKeesport suit). III., 1340, **5358-60.**

In testifying in McKeesport suit, assumed such utility as would make Sawyer & Man's invention patentable—that is to say, such a condition of affairs as would render the construction of individual lamps possible, having a capacity to operate as sources of light for such a time and in such a way as would fit them for some uses, even though such uses might be very limited or restricted. III., 1351, **5403.**

INVENTION INVOLVED—(*Continued*):

JOULE'S LAW:

explained. III., 1242, **4966.**

KING'S LAMP:

Prof. Morton calls attention to the old platinum lamps, and having stated that, "we certainly have no system of electric lighting by incandescence superior to that above described; nor has the older one or any of its newer rivals come into any general use," he refers to some difficulties involved in these and in carbon lamps, and says: "Though none of them have proved practically useful as yet, nevertheless some notice of methods of lighting by incandescence should be here given historically for future reference." After this follows the statement that the first incandescent lamp of record is that invented by Starr, for which an English patent was granted to King, in 1845, and which is known as the King lamp. Prof. Morton then states that, "This lamp has been modified in details until it has reached the form shown in Fig. 3, known as the Konn lamp. * * * Various modifications of this (Konn) lamp have been made and elaborately experimented with, but they all show the same essential characteristics." Here follow statements concerning the consumption of the carbon burner by oxygen and its vaporization: the development of less light by the lamp than by the electric arc: the rapid diminution of light as the current is distributed between a number of lights: that "another modification of this Starr or Konn lamp is found in that which has been recently exhibited in New York as the Sawyer-Man lamp;" and that while the carbon rods of the latter lamp are said not to waste away in the nitrogen atmosphere contained in the globe, he believes this is because they have "only been heated to the extent of yielding the light of one or two burners. Under these circumstances the carbons of the Konn lamp will last a long time; but, on the other hand, the light so obtained is not economical * * *" (Report of November 19, 1887, to Lighthouse Board). VI., 4134-7.

In his "Scribner's Magazine" article Dr. Morton says of this lamp, that "* * * a platinum wire is sealed through the top of a small glass chamber constituting the upper end of a barometer tube," and that the carbon burner at its lower end is electrically connected "* * * by a wire with the mercury in the barometer tube below. By passing a current through the platinum wire and thence through the upper clamp, carbon strip, lower clamp, wire and mercury, the carbon strip could be made incandescent, and was to a certain extent protected by the surrounding vacuum. Though this lamp produced a brilliant light, it proved in various respects unsatisfactory, and was abandoned after numerous trials" (Article in "Scribner's Magazine" for August, 1889). VI., 4362.

KING'S LAMP—(*Continued*):

Torricellian method of producing a vacuum is not a commercially practicable one. The deficiency was not supplied until after date of King's and Roberts's patents. The high vacuum afterwards obtainable with Sprengel and Geissler pumps would not be adequately preserved, unless heating during exhaustion, first applied to incandescent burners in 1878, were resorted to. III., 1348, **5392.**

At date of King's patent little or nothing was known as to art of making carbon burners. III., 1349, **5393.**

LAMP, ARC:

"Heretofore electric lights have only been practically developed in their concentrated form * * *" (Lecture of October 17, 1878). VI., 4083.

"Admirable as is the system of electric-arc lighting for use in streets and open spaces, and in workshops and large halls, it is entirely unfit to take the place of the numerous lights of moderate intensity employed for general domestic illumination" (Article in "Scribner's Magazine" for Aug., 1889). VI., 4360.

Principle upon which it works explained. III., 1232, **4926.**

LAMP CHAMBER:

In 1878 would have anticipated considerable difficulty from his own experience, and that of others, in attempting to obtain a perfect closure of chamber of Roberts's lamp by screwing the globe down air-tight upon the stopper or support. III., 1264, **5056.**

of Roberts's lamp was not an all-glass chamber, but had a metallic cap through which the leading wires passed, of which one at least was insulated from the cap by means of an ivory sleeve (McKeesport suit). III., 1272, **5085;** and 1312, **5246.**

Some form of lamp chamber is involved in first claim of Edison's Canadian patent, since the carbon filament could not be used in open air. The claim is not limited to any special form of chamber (Canadian suit). III., 1278, **5109-10.**

of Konn's lamp described in English patent No. 3809, of 1872, is not one made wholly of glass (McKeesport suit). III., 1319, **5272.**

History of art prior to Sawyer-Man patent does not show a lamp structure like or equivalent to theirs (McKeesport suit). III., 1337, **5346.** Note: The lamp chamber referred to consisted substantially of a glass globe and a separate glass base, with ground glass joint. The leading wires pass through, and are cemented into the glass base.

LAMP CHAMBER—(*Continued*):

Invention was involved in placing a carbon burner made from carbonized fibrous or textile material in an hermetically sealed lamp chamber, made wholly of glass (separable glass base), from which all carbon consuming gases have been expelled, and in having leading wires pass through and hermetically sealed (cemented) into the glass, as described and claimed by Sawyer and Man (McKeesport suit). III., 1340, **5358-60.**

A carbon burner made from carbonized fibrous material must be protected from air, and therefore must be enclosed in a chamber made wholly of glass (McKeesport suit). III., 1341, **5364.**

LAMP, INCANDESCENT:

Says, in speaking of the account of Edison's carbon lamp: "No one can more thoroughly appreciate than I do the originality of conception, the indefatigable patience and immense labor which has been involved in the series of experiments of which a sketch has been given in the 'New York Herald' of Sunday, the 21st. * * *" Considers that the lamp will be recognized as a conspicuous failure, however, and does not see in it anything different from the "* * * old method repeatedly tried and abandoned by others * * *" (Letter of December 22, 1879, to the "Sanitary Engineer"). VI., 4163-4.

Principle upon which it works explained. III., 1229-30, **4916-19;** and 1231, **4924.**

All the different sorts of lamps are operated by the passage of an electric current through a burner of high total resistance and small size, the resistance together with sufficiently small mass being secured by length, small cross-section and high specific resistance. III., 1231, **4924.**

Shepard's lamp, described in English patent No. 13,302, of 1850, is not an incandescent, but a semi-incandescent lamp, operating on an entirely different principle (McKeesport suit). III., 1312-4, **5248-54.**

of low resistance for use in series have been commercially manufactured since 1883 (McKeesport suit). III., 1345, **5378.**

LEADING WIRES:

in lamps having thin burners can be smaller than in those having thicker burners. III., 1261, **5044.**

MASS:

of burner of incandescent lamp and its radiating surface must be small, so that it can be intensely heated with minimum amount of heat. III., 1230, **4920.**

MASS—(*Continued*):

A small mass and radiating surface in the burner of an incandescent lamp are demanded, in order that the lamp may replace a source of light of moderate intensity, like a gas burner or domestic lamp. A large mass and surface, if the burner were heated to economical incandescence, would result in development of a light of many hundred candle-power. III., 1231, **4923.**

All the different sorts of incandescent lamps operate by the passage of an electric current through a burner of high total resistance and small size, the resistance, together with a sufficiently small mass, being secured by length, small cross-section and high specific resistance. III., 1231, **4924.**

MULTIPLE ARC:

Speaking of circuit arrangements, Dr. Morton says: "The first (series) method has certain drawbacks which are specially important in the case of incandescent lamps, where, for economy, a large number should generally be operated in a single circuit:

1. The extinction of one lamp means the extinction of all, unless some more or less complicated mechanism is provided to restore the connection around the lamp which has failed or has been turned out.
2. The electro-motive force, or electric pressure, needed to be multiplied in direct proportion to the number of lamps in the circuit soon becomes inconveniently high.

Both these difficulties being avoided in the 'parallel' (multiple arc) system, this last has been generally adopted by all the companies using incandescent electric lights for most of their works" (Article in "Scribner's Magazine" for August, 1889). VI., 4367-8.

Lamps in use to-day in multiple arc, with a high electro-motive force, have a resistance of fifty ohms and upwards; usually one hundred ohms or more. Series lamps, where the electro-motive force available for each lamp is relatively low, have a resistance of less than one to eight ohms. III., 1234, **4933.**

arrangement of electrical translating devices explained. III., 1236, **4942.**

OHM:

is the unit of resistance. A copper wire one-sixteenth of an inch in diameter and 378 feet long, a platinum wire of same diameter 70 feet long, and an arc light carbon, also of same diameter and about one inch in length, have each a resistance of one ohm. III., 1236, **4943.**

Ohm's law explained. III., 1239-40, **4956-7.**

PATENT IN SUIT:

The main feature of the invention and process described in Edison's Canadian patent, which, according to the statement of said patent, reversed prior practice, is the carbon filament. Aside from the fact of the use of this carbon filament of high resistance, the other items (meaning certain statements made in the patent, which are set out in the question) were old (Canadian suit). III., 1280, **5117.**

RADIATING SURFACE:

of burner of incandescent lamp and its mass must be small, so that it can be intensely heated with minimum amount of heat. III., 1230, **4920.**

A small radiating surface and mass in the burner of an incandescent lamp are demanded, in order that the lamp may replace a source of light of moderate intensity, like a gas burner or domestic lamp. A large radiating surface and mass, if the burner were heated to economical incandescence, would result in development of light of many hundred candle-power. III., 1231, **4923.**

RESISTANCE:

The early Edison lamp with "horseshoe" carbon, which was tested by Prof. Morton, had a hot resistance of 76 ohms (Tests, published in the "Telegraphic Journal" for May 1, 1880). VI., 4240.

All the different sorts of incandescent lamps are operated by the passage of a current through a burner of high total resistance and small size, the resistance, together with a sufficiently small mass, being secured by length, small cross-section and high specific resistance. III., 1231, **4924.**

in carbon pencils of an arc lamp subserves no useful purpose, and the pencils would be ideally perfect, if absolutely without resistance. On the other hand, resistance in the carbon burner of an incandescent lamp is a vital element. With little or no resistance such burner would be absolutely useless and incapable of operation. III., 1232, **4927-8.**

of arc light carbons cannot be too low, and all efforts have been directed to securing lowest possible resistances by large cross-section and electroplating with copper as thick as can be practically used. On the other hand, the resistance of incandescent burners is made as high as is consistent with the electro-motive force available for operation of the lamp, and with the capacity to construct a durable burner. The resistance of lamps used to-day in series, and where, therefore, the electro-motive force available for each lamp is relatively low, varies from less than one to eight ohms. Resistance of lamps used in multiple arc, and where available electro-motive force is much higher, varies from fifty ohms upwards; usually one hundred ohms or more. III., 1234, **4933.**

of defendants' Zig-zag lamp is 75 ohms, and of defendants' M lamp, 41 ohms, when they are heated by the normal current intended to operate them. III., 1269, **5076.**

RESISTANCE—(*Continued*):

The effective or actual resistance of a lamp is its resistance when hot. III., 1270, **5078.**

Burners of uniform resistance are readily produced by using fibrous vegetable material, because a uniform structure and cross-section are obtainable, and mineral matters are absent (McKeesport suit). III., 1273, **5091.**

to the current afforded by carbon is that which causes it to become incandescent (Canadian suit). III., 1278, **5112.**

of filament of Edison's lamp is high, partly because it is very thin and a very fine thread and filament (Canadian suit). III., 1279, **5114.**

RESISTANCE, SPECIFIC:

of material of burner of an incandescent lamp must be high, and its cross-section small in proportion to its length, in order to obtain a sufficient resistance, together with small mass and radiating surface, so that it will be intensely heated with minimum amount of heat. III., 1230, **4920.**

of the carbon in arc lamps cannot be too low, and all efforts have been directed to securing the lowest possible resistance by electro-plating with copper as thick as can be practically used. This increases the conductivity of the pencil. III., 1233, **4930.**

of carbon diminishes with increased temperature, and at incandescence is a little more than half what it is when the carbon is cold. III., 1269, **5075.**

For the production of a commercially successful incandescent lamp a fibrous vegetable material possesses a special advantage, in that after carbonization the resulting product has a high specific resistance, which property is of great importance and value in an incandescent lamp, although undesirable in arc light carbons (McKeesport suit). III., 1273, **5089.**

Carbon from fibrous or textile material would be "peculiarly *unfit*" for arc or semi-incandescent lamp pencils, because their specific resistance should be as low as possible. They would be ideally perfect, if with no resistance (McKeesport suit). III., 1273, **5092**; also 1326 and **5303.**

That uniformity in resistance of carbon which is called for in incandescent burners is not at all required in arc light carbons (McKeesport suit) III., 1274, **5094**; also 1327, **5305.**

of carbon should be high in burners to be used either in series or in multiple arc, but it is of more importance for multiple arc than for series burners (McKeesport suit). III., 1275-6, **5100-1**; also 1336, **5343.**

RESISTANCE, SPECIFIC—(*Continued*):

Filament of first claim of Edison's Canadian patent "must be of carbon of high resistance" (Canadian suit). III., 1277, **5108.**

Arc lighting could not be carried on commercially if carbon made from fibrous or textile material were used, because of its high specific resistance and low resistance to combustion (McKeesport suit). III., 1328-9, **5312-3.**

state of art prior to 1880 would have led one away from thought of making an incandescent burner out of carbonized fibrous or textile material, and to adopt a hard carbon, such as gas coke, as being the best material to use (McKeesport suit). III., 1329, **5314.** Note: Hard carbon is of low specific resistance.

SERIES:

Speaking of circuit arrangements, Dr. Morton says: "The first (series) method has certain drawbacks which are specially important in the case of incandescent lamps, where, for economy, a large number should generally be operated on a single circuit:

1. The extinction of one lamp means the extinction of all, unless some more or less complicated mechanism is provided to restore the connection around the lamp which has failed or has been turned out.
2. The electro-motive force, or electric pressure, needed to be multiplied in direct proportion to the number of lamps in the circuit soon becomes inconveniently high.

Both these difficulties being avoided in the 'parallel' (multiple arc) system, this last has been generally adopted by all the companies using incandescent electric lights for most of their works" (Article in "Scribner's Magazine" for August, 1889). VI., 4367-8.

Lamps in use to-day in series, where the electro-motive force available for each lamp is relatively low, have a resistance from less than one to eight ohms. Resistance of lamps used in multiple arc, where a higher electromotive force is available, varies from fifty ohms upwards; usually one hundred ohms or more. III., 1234, **4933.**

arrangement of electrical translating devices explained. III., 1236, **4942.**

lamps of low resistance have been commercially manufactured since 1883 (McKeesport suit). III., 1345, **5378.**

SHAPING:

Roberts's patent contains not the remotest suggestion as to employing a fibrous or textile material, which might be shaped before carbonizing, as the material out of which to make a burner (McKeesport suit). III., 1271, **5082**; and 1311, **5242.**

SHAPING—(*Continued*):

For the production of a commercially successful incandescent lamp, facility for shaping before carbonization is a special advantage possessed by fibrous vegetable material (McKeesport suit). III., 1272, **5088.**

prior to carbonization is of no practical value in making arc light pencils, because the materials are readily and usually gotten into shape while in the condition of powders already carbonized (McKeesport suit). III., 1274, **5093**; also 1326, **5304.**

after carbonization would be extremely difficult in any case, and impossible if it were attempted to make the burner of an arch form (McKeesport suit). III., 1330, **5318.**

Instructed to use paper, a person would bend or cut it into shape before carbonizing it (McKeesport suit). III., 1296, **5182.**

Using a fibrous vegetable or textile material, a skilled person would naturally cut it, in shaping, parallel with the fibres (McKeesport suit). III., 1299, **5196.**

STABILITY:

"Lamps in all essential respects like these described by Mr. Edison have been in constant experimental use for several years past with one invariable result, namely, that while the carbon would operate from a few hours to several days, it has been found utterly impossible to render them reliably permanent" (Interview published in "New York Times" of December 28, 1879). VI., 4166.

The question of mechanical strength is immaterial when arc light carbons are considered, as their size is sure to make them sufficiently strong to resist any shock to which they would be exposed (McKeesport suit). III., 1274, **5094**; also 1326, **5304.**

Carbon from fibrous vegetable material possesses mechanical strength, enabling it to resist shocks and strains (McKeesport suit). III., 1273, **5090.**

Burners of modern lamps, if straight, would be very liable to break, because in expanding they would be liable to bend at one point, and on shrinking would be subjected to a tensional strain. This liability to fracture was recognized prior to 1880, and some inventors attempted to overcome it by making use of yielding supports at the ends of the burner (McKeesport suit). III., 1333-4, **5332-3.**

SUBDIVISION:

After stating that the first incandescent lamp was invented by Starr, for which a patent was granted to his agent King, in 1845, and that it had been modified until it assumed the form known as the Konn lamp, the lecturer says of these lamps that "the third characteristic is the manner in which the light-producing power of the current diminishes as it is distributed between a number of lamps. Thus, the current from a given battery, acting on one lamp, produced a light between 4 and 5 burners; on two lamps a light of 1½ burners each; on three lamps, one-third to two-thirds of a burner each. From another battery the current in a single lamp gave a light of 11 to 12 burners; with two lamps, one-half burner each; and on three lamps, one-ninth of a burner each. In another case a given battery with one lamp gave the light of 9 burners; with two lamps, 2½ burners; and with three lamps, one-third of a burner each. Another lamp with one battery gave a light of 65 burners; with two lamps, 7½ burners; with three lamps, 1¼ burners; with four lamps, three-fourths of a burner; and with five lamps, one-half burner each. In this connection it is curious to notice that the latest accounts from Mr. Edison show that he gets a light equal to about 48 candles, or three argand gas burners, per horse-power with his new device, and, with similar machines for producing the electric current and the electric arc, from 1,000 to 2,000 candles per horse-power, thus showing remarkable agreement with these earlier experiments as to the loss of effect resulting from the subdivision of the light." After describing the Werdermann semi-incandescent lamp, and referring to the assertion, purporting to come from the inventor, to the effect that he could distribute the current from the two horse-power Gramme dynamo then employed, so as to divide it among 60 lights, Professor Morton says: "It will be noticed that here, as with all other lamps working by incandescence, there is great loss, which increases with subdivision. A Gramme machine utilizing two horse-power should give, with an ordinary (meaning arc) lamp, a light of from 1,000 to 1,500 candles, in place of the 640 claimed from two lamps, or the 400 candles claimed for ten lamps. A yet more recent system is that developed, or, we might rather say, now in course of development, by Professors Elihu Thomson and Edward Houston, of Philadelphia, which they themselves described as follows. Here follows a description of the Thomson-Houston vibrating arc lamp. Professor Morton says in conclusion that: "Heretofore electric lights have only been practically developed in their concentrated form, and it certainly has *not* yet been shown that when divided there will be an enormous loss of efficiency. Gas, on the contrary, has heretofore only been practically used in its divided form, and there can be no doubt that its efficiency is capable of much increase when it is burned in a concentrated manner. It is here where the actual contest will come in, and the relative success of the two sources of light in each field will depend upon what it will accomplish in that field and not in some other. In other words, we must compare the divided electric lights (say, Mr. Edison's, when they become visible) with ordinary (gas) burners, and the electric arc light with the lime light, or some such concentrated form of gas burning" (Lecture of October 17, 1878). VI., 4070, 4082½, 4083.

SUBDIVISION—(*Continued*):

Prof. Morton states that the King lamp has been modified until it has reached the form illustrated, known as the Konn lamp, and that all modifications of this lamp show the same essential characteristics, of which "the third characteristic is the manner in which the light producing power of the current diminishes as it is distributed between a number of lamps," as illustrated by results of experiments which follow (Report of November 29, 1879, to Lighthouse Board). VI., 4136-7.

"Dividing the electric light" means the economical production of small electric lights (Interview published in "New York Times" of Dec. 28, 1879). VI., 4167.

New York "Tribune" for October, 1878, contains report of Morton's lecture before the American Gas Light Association in part as follows:

"Illustrations and Experiments.

Now, among these productions I propose to name and illustrate a few, such as our time will admit. In the first place, lights of moderate intensity may be produced by heating a substance through which the electric current passes; and this I will illustrate by heating a platinum wire. (A glass jar, through which a platinum wire had been run, was placed on the lecturer's desk, and the ends of the wire were connected with the poles of a battery. The platinum wire glowed with heat and emitted a mild, yellowish light, equal in intensity to that of an ordinary lamp. Prof. Morton explained that the light was caused by the resistance in the wire, which produced heat, and that the wire would be consumed if heated beyond a certain point.) Hundreds of experiments have been already made on this subject both in this country and abroad, and these are numerous patents and devices of lamps in which this is the ruling feature. In all of these there is this feature of difficulty: As soon as the intensity of the light is diminished by subdivision, the percentage of light enormously decreases, so that when a given electric force, being applied to one lamp, produces a light of, say, 80 burners, divided into two lamps it falls off into 30 burners for the two, and so on. * * * The electric light has its field, and it is a vast one. But that field is not certainly in the near future—that of what we may call private illumination of dwelling houses and the like."

Admits that above is a fair report of what was said, but that, in speaking of loss by subdivision, he had in mind the loss which would take place with arc lamps, and further, that electricity would not become a general substitute for gas in lighting private houses. III., 1368-70, **5472-80.**

UTILITY:

Does not recognize that the Edison carbon lamp, described in the "New York Herald," is different from those made by the "* * * old method repeatedly tried and abandoned by others" (Letter of December 22, 1879, to the "Sanitary Engineer"). VI., 4164.

UTILITY—(*Continued*):

In testifying in McKeesport suit, assumed such utility as would make Sawyey & Man's invention patentable, that is to say, such a condition of affairs as would render the construction of individual lamps possible, having a capacity to operate as sources of light for such a time and in such a way as would fit them for some uses, even though such uses might be very limited or restricted. III., 1351, **5403.**

In my "Times" article, in referring to the success of the Edison lamp described in the "Herald" article, I admitted its technical operativeness, but did not believe it would have that degree of success which would make it a competitor with and displace gas. In stating that the described lamp lacked new properties, I had in mind the fact that the burner was made of carbonized paper. III., 1359, **5434.**

Note.—Paper is made from vegetable fibrous material. Such material was one subject of controversy in McKeesport suit.

VACUUM:

In speaking of King's lamp, Dr. Morton says "* * * the carbon strip could be made incandescent and was to a certain extent protected by the surrounding vacuum. Though this lamp produced a brilliant light, it proved in various respects unsatisfactory, and was abandoned after numerous trials" (Article in "Scribner's Magazine" for August, 1889). VI., 4362.

Speaking of radiometers, Dr. Morton says: "Indeed, as was subsequently made apparent, the wonderful results obtained by Dr. Crookes in the production of very perfect vacua were of essential importance to the development of the incandescent electric lamp" (Article in "Scribner's Magazine" for August, 1889). VI., 4364.

In 1878 would have anticipated considerable difficulty from his own experience and that of others in attempting to obtain a perfect closure of chamber of Robert's lamp by screwing the globe down air-tight upon the stopper or support. III., 1264, **5056.**

A carbon burner made from carbonized fibrous material must be protected very thoroughly from access of air, and therefore must be enclosed within a chamber wholly of glass (McKeesport suit). III., 1341, **5364.**

Torricellian method of producing a vacuum is not a commercially practicable one. The deficiency was not supplied until after date of King's and Roberts's patents. The high vacuum afterwards obtainable with Sprengel and Geissler pumps would not be adequately preserved, unless heating during exhaustion, first applied to incandescent burners in 1878, were resorted to. III., 1348, **5392.**

24

MORTON, Dr. Henry.

VACUUM—*Continued*):

The art of producing and maintaining a perfect vacuum had been carried to a point of practical efficiency prior to 1879. III., 1349, **5396.**

Known prior to 1879 how to produce and maintain vacuum in such apparatus as a Geissler tube, but the Sawyer-Man process of removing occluded gases gave the means for maintaining such a vacuum under the conditions involved in the use of an incandescent lamp where the carbon burner, its enlarged ends, and clamps and leading wires were likely to give out occluded gases. III., 1365, **5459.**

Note.—Sawyer-Man process referred to was first applied in 1878. III., 1348, **5392.**

VOLT:

is the unit of electrical pressure, or electro-motive force. One cell of Daniells' battery has an electro-motive force of about one volt. III., 1237, **4945.**

WATT:

Meaning of term explained. III., 1238, **4949.**

MYERS, Lawrence:

is a negotiator of railroad bonds. Was a director in the Electro-Dynamic Light Co.

BURNER OF CARBON:

There were several forms of burners used by Sawyer-Man at the corner of Walker and Elm Streets; some were straight, some an inverted V-shape, and some in the form of an arch; some were made of willow, some of black carbon rubbed down with sand paper and other things. I do not know that any of the burners I saw there were made of carbonized paper. I saw Mr. Sawyer put the carbons that they made into a lamp (Interference Record). II., 1155-6. **4619-23.**

CARBONIZATION:

I saw, at the corner of Walker and Elm Streets, in 1878, Mr. Sawyer and Mr. Man making carbon burners; saw them make them from various things; they put them in a crucible in a furnace and put molasses, &c., on the material (Interference Record). II., 1156. **4621-2.**

CROSS-SECTION:

The carbons made by Sawyer-Man at Walker street were about the size of a good-sized knitting needle (Interference Record). II., 1157. **4625.**

SHAPING:

When Mr. Sawyer put the carbons in the lamps at Walker Street, he took a block of carbon and sawed out the arch, then reduced it by sand paper or a file to the size he desired, and put it into the holder and secured it (Interference Record). II., 1157. **4625-6.**

NEWSPAPERS.

CENTRAL STATION LIGHTING:

As to the progress being made in central station lighting in New York City by the Edison Company, as reported in the "Review of the Telegraph and Telephone" and "New York Herald," it "will be seen from these articles, there is every probability of the success of the Edison system in New York, and as soon as the lower district has been lighted up work will be commenced in Paterson" ("Electricity or Gas," published in "Paterson Daily Press," September 2, 1882). VI., 4419.

COMPETITION WITH INFRINGING COMPANIES:

As to Edison's system of lighting, Mr. Bliss, superintendent of the Western Edison Company, says: "They (the capitalists interested) begged him (Edison) to let them introduce it to the public, so that other and inferior systems might not get a start. He was inexorable. It was his determination that every needed generator, conducting wire, switch cut-off and lamp, no matter where to be used, or whether supplied by overhead connections or underground, should be completed and tested before a single light should be placed in position outside of Menlo Park. The result has proven his wonderful prescience to have been well exercised. Not a solitary failure of the Edison light has, in consequence, been anywhere reported. On the other hand, not one of the other systems have escaped numberless failures, and that in many and important directions" (Interview published in "The Daily Gazette," at Davenport, Iowa, May 22, 1883). VI., 4423.

INFRINGEMENT:

"The number of incandescent lamp systems now before the public and backed by capital appears to be four—the Edison, Maxim, Swan and Lane-Fox. In general construction and fundamental principle these lamps are practically alike—all heat to incandescence a filament of carbon in a glass globe from which the air has been exhausted." The companies now controlling these systems are taking steps to place their lamps on the market, and this will probably lead to a legal contest of great magnitude. "This unfortunate strife, which threatens to damage the interests of all concerned in the incandescent system of electric lighting, appears to be set on foot by the 'Edison Light Company' of the United States, who claim 'the sole right to manufacture and sell the incandescent lamp, consisting of a carbon filament in a vacuum, under whatever name that lamp may be known.' It will be noticed, after this explanation, that such a claim covers the fundamental principle of the lamp. If

INFRINGEMENT—(*Continued*):

it can be maintained in a court of law, all other systems will have to abandon their business or pay any royalty which the Edison Company may demand." Here follow statements made by Mr. Eaton, of the Edison Company, for which, see Eaton, Infringement ("An Electric Light War," published in "New York Commercial Advertiser," August 8, 1882). VI., 4409-10.

The president of the United States Electric Light Company, who own the Maxim incandescent lamp, says to the reporter of the "Commercial Advertiser": "You have the credit of publishing in specific terms what the Edison Company claim in this respect (the monopoly of incandescent lighting is referred to), but we, of course, know that they proposed to make such a claim. We repudiate it altogether, and shall continue our business as before. * * * A printed form was sent to us from the Edison Company which referred to an infringement; but, although we are doing a large business with this lamp, we have not been restrained by any legal notice." An officer of the New England Electric Light Company, who control the Swan lamp for the United States, says that he has read the article in the "Commercial Advertiser" respecting Edison's claim to a monopoly of the incandescent lamp, but that they had paid little attention to it, regarding the claim as fallacious ("The Electric Light War," published in "New York Commercial Advertiser," August 10, 1882). VI., 4412-3.

"With regard to the rumors of important patent suits between the different companies making incandescent electric lamps, the Edison Company claims a monopoly of the business upon the following grounds: That it has patents covering (1) a continuous conductor, the light-giving filament forming part of the circuit; (2) a filament of carbon; (3) high resistance—something never before obtained; (4) 'metallic leading-in' wires, ending in a clamp-like connection with the carbon; and (5) a process of manufacturing indispensable to the production of all and any of the incandescent lamps now in the market. When the Swan light, which the Brush Company is preparing to put upon the American market, is offered for sale, the Edison Company will begin suit for infringement, and also against the United States Electric Light Company should the Maxim lamp interfere with the business of the Edison Company ("Electricity or Gas," published in "Paterson Daily Press," September 2, 1882). VI., 4419.

Mr. Bliss, superintendent of the Western Edison Light Company, says: "* * * But beyond all, so far as we are concerned, the Maxim (lamp) is an infringement on the Edison light. Some months ago the Edison people commenced suits against the Maxim folks in France. For many weeks the papers and evidence have been preparing for similar suits in the United States, and these have just now been entered. So we are not in the least concerned about the pretended opposition of the Maxim light" (Interview published in "The Daily Gazette," at Davenport, Iowa, May 22, 1883). VI., 4425.

LICENSES GRANTED BY EDISON COMPANY:

Mr. John Reynolds, president of the Paterson Gas Light Company, is reported as saying that a number of gentlemen connected with the United Gas Improvement Company are also interested in the Electric Light Company, and that the chances of the latter had been well canvassed and examined into before any arrangement with the Paterson gas companies had been entered into. The Electric Light Company was not a new one, but its operation could not be begun until the success of certain experiments in New York had been assured. The company was formed last winter (winter of 1881-2), and obtained a license of the Edison system on the understanding that, as soon as that system proved a perfect success, the company was to work up the cities in northern New Jersey, Jersey City, Hoboken, Newark, Paterson, Passaic, Rutherford and other places. The tests recently made by Edison seem to establish the success of his system. The work of the corporation which is to supply Paterson with light was begun as soon as the practical success of the system was established, and it is claimed that a large number of agreements with mill owners have been entered into. Quite a number of private residences will also be illuminated, and it is calculated that the business in Paterson will start with at least ten thousand lights to begin with ("Electricity or Gas," published in "Paterson Daily Press," September 2, 1882). VI., 4415-6.

"The company of which he (G. H. Bliss) is a member and an officer has a capital of $500,000, the shareholders in which embrace nearly forty of the foremost capitalists and business men of Chicago. * * * The sphere of action of this strong organization embraces the States of Illinois, Wisconsin, Iowa and Minnesota, wherein it controls all the franchise of the Edison electric light secured under the patents issued to Thomas A. Edison, the great inventor, and also under all patents yet to be issued to him, and the inventions to be made by him up to January 1, 1886. These franchises and rights are acquired under the Edison Company of New York, which own all of the Edison patents now issued, together with all to be issued, and the inventions yet to be made up to January 1, 1886" ("Edison's System," published in "The Daily Gazette," at Davenport, Iowa, May 22, 1883). VI., 4421.

O'BRIEN, Jeremiah:

is a grocer. Was employed by Wallace & Sons in the manufacture of carbon from 1877 or 1878 to 1887.

CARBON:

At Ansonia, I assisted in mixing the material from which the carbons were made, and in pressing it through the dies or nozzles to form it into wires or pencils. After they were made, the pencils were placed in the fire and baked. II., 1188, **4751-2.**

The majority of the carbons made by Wallace & Sons were for electric lights like the Brush and Thomson-Houston lamps. I do not know whether the material was the same in the millimeter as in the seven-sixteenth carbons. II., 1191-3, **4763-4** and **4470.**

CROSS-SECTION:

The cross-section of the carbons made at Wallace & Sons, Ansonia, varied. In May or June, 1879, I made carbons having a diameter of the "Hayes Carbon No. 1" (diameter thirty-one and one-half thousandths of an inch), and of the millimeter size. We made in 1879, 1880, and afterwards, a great many of the Hayes Carbon No. 1. The greater number of all the carbons made by Wallace & Sons were seven-sixteenths of an inch in diameter. The other sizes were one-quarter inch, and one-quarter inch by two and one-half inches, and nine inches long. When I left Wallace and Sons the sizes being made were seven-sixteenths of an inch in diameter and twelve inches long; one-quarter inch in diameter and twelve inches long; five-eighths of an inch in diameter and twelve inches long; three-quarters of an inch in diameter and twelve inches long; five-sixteenths of an inch in diameter and twelve inches long. These latter were the smallest made at Wallace's when I left. Very few of the smaller size were made, but the seven-sixteenths carbons were made by the thousands. II., 1189-92, **4754-4766.**

ELASTICITY AND FLEXIBILITY:

The smaller carbons made at Ansonia, when they were ready for use, were rigid, and not flexible and elastic. II., 1194, **4774.**

OUTERBRIDGE, A. E., Jr.

FILAMENT OF CARBON:

"It appears to me that Mr. Edison, while using the same materials and similar apparatus to that of his predecessors, has in point of fact made quite a new departure in the employment of a new form of a familiar material which thus offers, *in a short circuit*, an enormous resistance (100 ohms) in conjunction with a current of sufficiently high tension to overcome that resistance with the smallest possible sacrifice of power, thus really discovering a new path through a field which had already been prospected by numerous explorers. Whether this 'lead' reveal a mine or prove a mere *ignis fatuus* I will not venture to predict." (Lecture on "The Edison Electric Light," of January 21, 1880.) VI., 4218.

STABILITY:

"There is a small glass bulb, into the neck of which is introduced a small bulb, containing two platinum wires, hermetically sealed, and terminating inside the lamps in two little metal clips which hold the delicate horseshoe shaped filament of carbonized paper (when I say delicate I do not mean fragile, for these little conductors are wonderfully tough and elastic, as I proved by twisting and breaking several which Mr. Edison gave me for the purpose of testing their strength)." (Lecture on "The Edison Electric Light," of January 21, 1880). VI., 4216.

UTILITY:

Referring to the old carbon lamps the lecturer says: "Starr's schemes were prematurely extinguished on account of his sudden death, but he was followed by a number of others who produced incandescent lamps depending on the same principles, all of them promising in their embryonic stage brilliant prospects of future usefulness, but they have all failed to fulfill the expectations of their sanguine authors, and have remained buried in almost complete oblivion. It is not unnatural, therefore, that scientists who are cognizant of the immense difficulties in the way of a practical solution of a problem which is, in theory, extremely simple, should hesitate to concede a better fortune to this latest child of even so herculean an inventive genius as Mr. Edison." (Lecture on "The Edison Electric Light," of January 21, 1880.) VI., 4213.

PHALAN, Jas. H.:

was employed by Wallace & Sons from 1871-1881, and assisted Mr. Sawyer in all his work at Ansonia; is a tool-maker by occupation.

BURNER OF CARBON:

In June or July, 1879, I saw burners that were of a balloon shape. I think Mr. Sawyer brought them with him to Ansonia. They were flexible and tough and seemed to be made of paper. They were cut out with shears from pieces about 3 inches square. II., 1207-8, **4825-4829.**

CLAMPING:

The balloon-shaped burners used by Mr. Sawyer in June or July, 1879, were attached to the leading wires by means of clamps. II., 1206, **4822-4824.**

I saw Mr. Sawyer use straight pencils of carbon in a lamp in which there were permanent contacts at both ends of the carbon. II., 1208, **4832.**

CROSS-SECTION:

I saw Mr. Sawyer use, at Ansonia, carbon burners as small as 31¼ thousandths to 50 thousandths of an inch in cross-section, and have seen him use them as large as 1-16 of an inch in diameter. II., 1205, **4818-4820.**

The balloon-shaped carbons used by Mr. Sawyer at Ansonia in June or July, 1879, had a cross-section of ⅛ of an inch, and were about 6-thousandths of an inch thick. II., 1208, **4830-1.**

The diameter of the burner in the "Sawyer lamp produced by Hayes" is fifty thousandths of an inch. We found this size the most economical to use, as the others took too much current—the larger ones—and the smaller ones would burn off too quickly. II., 1211, **4842-3.**

HYDRO-CARBON TREATMENT:

Mr. Sawyer, at Ansonia, subjected the carbon burners to hydro-carbon treatment. I saw him place carbon burners in oil and heat them with the electric current. II., 1205, **4817.**

SAWYER'S FEEDER LAMP:

At Ansonia, Mr. Sawyer used other lamps than the feeder lamps. These were like the feeder lamps, except that that the feeding tube and mechanism were omitted, and the upper rollers were replaced by a clamp. There were very few of this kind, and the work was done principally on the feeder lamps. The feeder lamps had a defect that showed itself very frequently. When the rolls did not press closely enough together, an arc would form between the rolls and the carbon, which would burn off the carbon and make a flat place on the rolls. II., 1210, **4837-40.**

SHAPING:

In June or July, 1879, I saw Mr. Sawyer use carbon burners that were cut from a straight piece of carbon and bent into a balloon shape. II., 1206-7, **4822-4824.**

PREECE, W. H.:

States that he is electrician to the (British) Post-Office. VI., 4115.

SUBDIVISION:

"The theory of the electric light cannot be brought within the domain of quantitative mathematics, for the reason that we do not yet know the exact relation that exists between the production of heat and the emission of light with a given current; but we know sufficient to predict that what is true for the production of heat is equally true for the production of light beyond certain limits." The author then considers mathematically the question of the heat generated in lamps arranged both in series and in multiple arc, with a generator of constant electro-motive force, and, in the latter case, assumes, for the purposes of argument, that the combined resistance of all the lamps in multiple arc is so low, as compared with that of the conducting wires and generator, that it may be neglected. (This assumption would not be a permissible one to make when, as in modern practice, the resistance of the individual lamps is high and that of the generator and conducting wires is low.) Preece concludes that, contrary to what is the fact as far as modern multiple arc incandescent lighting with high resistance lamps is concerned, "* * * *joined up either in series or in multiple arc, the heat generated in each of a number of resistances varies inversely as the square of their number.*" Upon this basis as to the heat generated, the writer states that, "with respect to the light emitted, if the amount of heat generated represented exactly the amount of light emitted, then the above equations would indicate the effects produced by multiplying the lights or subdividing the current when a constant battery is employed. But this is not so." (It is in modern lamps, because the ratio between the heat generated and the extent of the radiating surface of the burner is kept constant.) "Below a certain limit the production of heat is not accompanied by light at all. In the case of incandescence, if the heat be distributed over two wires instead of one, inasmuch as the mass to be heated in the one case is double that in the other, the actual temperature to which each of the wires will be heated will be only one-quarter of that obtained with one wire, and the *total* light emitted will be half what it was before. In the case of the arc a *similar* result probably takes place. * * * If, therefore, the lamps be joined up in series or in multiple arc, the light emitted by each lamp will vary inversely in a greater ratio *than* the square of the number in circuit." Upon another assumption that the dynamo is generating a constant amount of electrical energy, irrespective of the number of lamps in circuit; and, again, assuming the combined resistance of the lamps when arranged in multiple arc so low as to be negligible, the writer concludes that, beyond certain limits, the light diminishes as the square of the num-

PREECE, W. H.

SUBDIVISION—(*Continued*):

ber of lamps in series, or as the cube of the number of lamps in multiple arc. "We have assumed W" (the total heat generated in the circuit), "to be constant; but this is only the case when a certain limit is reached and when the velocity of the rotating coils in the dynamo machine has attained a maximum. This limit will vary with each dynamo machine and each kind of lamp used. With the Wallace-Farmer machine the limit appears to be reached when six lamps are connected up in series. With the Gramme alternating machine and Jablochkoff candles the limit appears to be five lamps. Beyond these limits the above laws will be true. It is this partial success in multiplying the light that has led so many sanguine experimenters to anticipate the ultimate possibility of its extensive subdivision—a possibility which this demonstration shows to be hopeless, and which experiment has proved to be fallacious. *Vide* Fontaine's 'Electric Lighting,' Chapter XI." (Paper on "The Electric Light," January, 1879). VI., 4084-90.

Speaking of the Wallace and Rapieff arc lights, the lecturer says: "In these two instances six lights are used in one circuit, but we have not here the subdivision of the light; we have, on the contrary, the multiplication of the light produced by the increased speed of the engine, due to the insertion of additional lamps. It is, however, easily shown that in a circuit where the electro-motive force is constant and we insert additional lamps, then when these lamps are joined up in one circuit, *i. e.*, in series, the light varies inversely as the square of the number of lamps in circuit, and when joined up, as in multiple arc, the light diminishes as the cubes of the number inserted. Hence, the subdivision of the light is an absolute *ignis fatuus*" (Lecture on "The Criteria of the Electric Light," February 15, 1879). VI., 4093-4.

States that he has considered the question of subdivision of the current for the production of various lights both theoretically and experimentally; also that the conclusions arrived at by him are to the effect that when lamps are connected in series, the light of each lamp diminishes as the square of the number of lamps connected, or as the cube of the number of lamps, if they are arranged in multiple arc, "showing that when you attempt to subdivide the light beyond two or three, intensity of the light diminishes in a marvelous ratio." * * * "It is only economical when one machine is used to produce a single light." * * * "Any departure from that means waste, economically speaking" (Testimony before the Parliamentary Committee on Lighting by Electricity, May 2, 1879). VI., 4115.

SAWYER, Geo. W.

Was employed with his brother, William E. Sawyer, in all his electrical experiments from about 1871 or 1872 to 1881 or 1882. Was with his brother before and after the latter's acquaintance with Mr. Albon Man.

BURNER OF CARBON:

Prior to the time that my brother became acquainted with Mr. Man, he had not made anything that could be called an electric lamp, and had only heated generally pieces of lead pencil to incandescence in the open air. In the experiments at the Coal and Iron Exchange, pieces of retort carbon or lead pencil were enclosed in a Florence flask which was filled with illuminating gas (McKeesport suit). V., 3308-9.

The carbons used at Centre Street kept getting larger, the globes darkened, and the light became dimmer. The lamps were recharged with gas after the exhibition (McKeesport suit). V., 3310.

The carbon used in the lamps at Centre Street, was hard retort carbon worked into shape. The resistance was very low after the exhibition at Centre Street was over; the carbons had all increased in size (McKeesport suit). V., 3313.

I never saw or heard of any other than hard carbon, or retort carbon, being used in the lamps at Centre Street (McKeesport suit). V., 3314.

After we moved to the corner of Howard and Centre Streets nothing but hard or retort carbon was used (McKeesport suit). V., 3315.

After we moved to Walker Street, I think we had a few sticks of French carbon, but retort carbon was the principal material (McKeesport suit). V., 3316.

Retort carbon was the only form of carbon used in the feeder lamp made at Walker Street (McKeesport suit). V., 3317.

The willow twig carbons did not work as well as the hard carbons (McKeesport suit). V., 3317.

The willow twig carbons were generally a straight round pencil about three-quarters of an inch long. There were very few of them made, and after they ceased using them, they tried to permeate blotting-paper with the

BURNER OF CARBON—(*Continued*):

lead or plumbago of a lead pencil, and then heat them up with a machine and carbonize them, which cannot be done, as an electro-plating machine would not accumulate on a thing of such high resistance. I never saw any carbonized paper used in a lamp at Walker Street, or Centre Street. At Walker Street, but not at Centre Street, I saw hard carbon worked into an arched or horseshoe shape (McKeesport suit). V., 3319.

The horseshoe lamp, mentioned in the "New York Herald" of December 24th, 1879, was made at 94 Walker Street and had a burner of hard carbon worked into that shape. My brother believed that the shape was all that Edison was after, and said nothing as to any importance that he attached to the material of the burner. At this time my brother was working continually on the feeder lamp (McKeesport suit). V., 3319 and 3322.

My brother never believed Mr. Edison's claims or statements as to his success with the carbon burner in his lamps. He claimed that the lamps used in the illumination of Menlo Park were started when a train was due, and put out after it had passed. He laughed at Mr. Edison's claim that he had made a lamp having a thin carbonized thread for a burner (McKeesport suit). V., 3323.

CARBON:

Prior to the time of the Edison publication in the "New York Herald," my brother never spoke to me of paper carbon or vegetable fibrous carbon of any kind, as being important or in any special degree useful. He relied upon carbon of very low resistance, and about all that we knew anything about was retort carbon (McKeesport suit). V., 3320.

CARBONIZATION:

At Centre street we had only crude apparatus for conducting experiments—a charcoal furnace, such as chemists use, which was procured to heat a tube filled with copper turnings; it did not work (McKeesport suit). V., 3311.

I never saw at Centre Street any carbon made or any substance carbonized. We had no means for carbonizing, the furnace being only a plumber's furnace, and there being no fire-place in the room (McKeesport suit). V., 3314-5.

Nothing except some willow twigs, which were brought in by Mr. Man, was carbonized at Walker Street (McKeesport suit). V., 3317.

DURABILITY:

At Centre Street we had seventeen flasks, or lamp glasses, at one exhibition. They lasted no time at all, and we were glad to get the crowd out before

DURABILITY—(*Continued*):

everything would give out. The lamps were taken down, and recharged with gas. The burners increased in size. Some of the lamps had ground glass globes to diffuse the light (McKeesport suit). V., 3310.

I do not believe that we ever burned a lamp at Centre Street more than half or three-quarters of an hour at one time (McKeesport suit). V., 3314.

I have read the printed letter published by my brother in the "New York Sun," December 22d, 1879, in reference to Mr. Edison's invention, and I heard him say at different times that he believed he was perfectly right in the challenge he had made; he was sure nothing of the kind could be done (McKeesport suit). V., 3321.

Although the lamps at Walker Street were turned out after the visitors had gone and the carbons changed, my brother represented the lamps to Mr. Meyers and Mr. Man as burning continuously, and that in practical shape they would last forever. He told about lamps running a length of time when they had not done so. Mr. Man was not in a position to know the truth (McKeesport suit). V., 3324-5.

DYNAMOS:

In February, 1878, in an experiment at the Coal and Iron Exchange, we had only a few cells of battery (McKeesport suit). V., 3308.

In our Centre Street place there was an Arnoux & Hochhausen machine, but we only used it a few days before it was taken away. We afterward had a Ball machine and a Weston, but there was nothing done with them (McKeesport suit). V., 3310-11.

EVAPORATION:

The globes which were used in the experiments at the Coal and Iron Exchange in February, 1878, became so smoked that we could not tell how long the carbons were burning, and we opened them and looked at them (McKeesport suit). V., 3309.

FILAMENT OF CARBON:

My brother never believed Mr. Edison's claims or statements as to his success with the carbon burner in his lamps. He claimed that the lamps used in the illumination of Menlo Park were started when a train was due, and put out when it had passed. He laughed at Mr. Edison's claim that he had made a lamp having a thin carbonized thread for a burner (McKeesport suit). V., 3323.

GASES:

We charged the flasks used in the experiments in February, 1878, at the Coal and Iron Exchange with illuminating gas (McKeesport suit). V., 3308-9.

GASES—(*Continued*):

I do not know that we used any gas other than illuminating gas at Centre Street (McKeesport suit). V., 3312.

At Walker Street we charged lamps with nitrogen. We used to exhaust and allow the gas to flow in, and exhaust again and obtain the vacuum, by "dilution," as we called it (McKeesport suit). V., 3316.

HYDRO-CARBON TREATMENT:

The carbons of Sawyer & Man were generally treated by being immersed in some hydro-carbon oil, or in a hydro-carbon gas—illuminating gas—and then heated to a state of incandescence (McKeesport suit). V., 3319-20.

LAMP CHAMBER:

In our experiments at the Coal and Iron Exchange, in February, 1879, we used Florence flasks filled with illuminating gas. We put into the flasks a couple of uprights—conductors—to hold the piece of carbon, and tied the carbon around with copper wire, so as to make a connection, and there was a rubber cork in the flask. The globes became smoked, so that we could not tell anything about how long the carbons burned (McKeesport suit). V., 3308-9.

LAMP INCANDESCENT:

My brother had not made any experiments with the electric lamp for incandescence before the last of January, or the 1st of February, 1878 (McKeesport suit). V., 3309.

The feeder lamp was begun at Walker Street, and was made to obviate the necessity of taking the lamp apart, in order to have the carbon replaced. Only retort carbon was used in the feeder lamp (McKeesport suit). V., 3317.

My brother's experiments at Walker Street ended some time in 1879, on account of some trouble with the company, and they took some lamps and paraphernalia to Ansonia. No experiments with the lamps were made at Ansonia while I was there. I do not remember my brother making any further experiments on lamps from the time we left Walker Street up to the time of the publication of the Edison article in the "New York Herald" (McKeesport suit). V., 3327.

SAWYER-MAN WORKSHOP:

At Walker Street they had for machinery one or two lathes and a grinding-stone. They also had a kind of chemical set there. To get a vacuum they had a fall of water from the roof (McKeesport suit). V., 3315-7.

SEALING:

The lamps used at Centre Street differed from those experimented with at the Coal and Iron Exchange in the fact that the bottom of the lamp was differently sealed. A soapstone bar passed up inside, to prevent loosening the sealing by the conduction of heat, and a glass stopper was used for the flasks or lamps (McKeesport suit). V., 3312.

I think the lamps at Centre Street were closed by a flat stopper and fir balsam put in the joint. There was a flange cast on the upper globe, and some kind of metal clamp to clamp the stopper and globe together (McKeesport suit). V., 3312.

SHAPING:

The carbon used in the lamps at Centre Street was hard retort carbon worked into shape (McKeesport suit). V., 3313.

After the willow twigs, made at Walker Street, were carbonized, they were worked down into the desired shape (McKeesport suit). V., 3317.

I never saw any lamp with vegetable-carbon or paper carbon having the arched or horseshoe shape. At Walker Street I saw hard carbon worked into an arched shape. This was at the time of the publication of Edison's horseshoe lamp (McKeesport suit). V., 3319.

VACUUM:

At Walker Street my brother used to claim that there was one per cent. of air left in the globes. I don't know whether we really used the vacuum. Whether there was an absolute vacuum or not, we called it a vacuum, because there was no air. We used to exhaust and allow the gas to flow in, and exhaust, and allow the gas to flow in again, and obtain the vacuum by dilution, as we called it. There were some lamps tried in which the air was taken out and nothing put in, but they did not succeed so well as those charged with nitrogen, as we could not seem to get a vacuum. To obtain a vacuum, we had a fall of water from the roof of the house, which, by its fall, sucked out the air (McKeesport suit). V., 3317.

SAWYER, William E.:

Electrician. Associated with Mr. Albon Man in the Sawyer-Man inventions.

BURNER OF CARBON:

My experiments with a carbon horseshoe burner led Mr. Man and myself to conclude that it was not worth patenting (Letter to "New York Herald" and "New York World," of December 24, 1879). VI., 4170 and 4174.

"Over a year ago I experimented with the horseshoe lamp and found it a failure, even with the carbon much harder and more tenacious than paper carbons. Some dozen of these lamps were constructed (Letter to "New York World," of December 24, 1879). VI., 4173.

"The best artificial carbons for incandescent lighting that we (Sawyer and Man) have obtained are made by the Carré process. * * * Pencils of one thirty-second of an inch in diameter and nine inches in length, made expressly for us, are as absolutely straight and regular as a wire under tension" ("Electric Lighting," 1881). VI., 4292 and 4293.

Sawyer and Man early attempted to obtain a practical lamp by the use of an arch or loop of carbon. Retort carbon was first used for this purpose in March, 1878. In the following winter various substances in the form of a loop, particularly twigs of fine willow, were tried with varying results. "A year later Mr. Edison greatly improved the manufacture of these loops by processes much better calculated to obtain the end desired than those employed by Sawyer and Man, whose success in this direction was limited" ("Electric Lighting," 1881). V., 4313-4

In conjunction with Mr. Albon Man have many times made and used an incandescent conductor for an electric lamp formed of carbonized paper. The first time was about the sixth or seventh of March, 1878. At 43 Centre street, after I became associated with Mr. Man, I took some ordinary foolscap paper and drew some pencil marks upon it. When two copper wires connected with the generator were applied to the pencil marks, we got a little spark. Then Mr. Man and I took some blotting paper, drew a heavy pencil mark, making a crease, which we filled up with powdered graphite. This we brushed off so as to leave only what graphite was on the crease. When we had succeeded in getting a current through, we charred or burnt the paper. I suggested that the charred parts, being so fine, would probably make a good burner. Mr. Man then took a piece of blotting paper, one-eighth to three-sixteenths in width and from half an inch to one inch long, and pounded it full of graphite. On getting a current through it, the paper was destroyed. We then put strips in a

BURNER OF CARBON—(*Continued*):

sealed globe filled with ordinary illuminating gas, and passed a current through the strips while a stream of illuminating gas was flowing through the globes. We concluded that this was an expensive way to make carbons. Mr. Man and my father fixed up, from two pieces of iron, a box in which Mr. Man, at his house, carbonized some pieces of blotting paper. I would take the carbons, and, after treating them, put them in the lamps. My own idea was that a much harder carbon would be better than those thin, fragile paper carbons, but Mr. Man preferred the paper (Interference Record). II., 972-4. **3890-5.**

The burners of carbonized paper were generally in the form of a half-circle or circle, but we experimented with all conceivable shapes. Anything that would suggest itself as capable of allowing for the expansion and contraction of carbon was used. We also used a straight piece and a V-shaped piece (Interference Record). II., 975. **3897-8.**

Various forms of paper carbons, including the arch form, were sealed up in lamps and run: The great trouble with them was that when we raised the temperature till we could get a bright light they would break; for this reason I preferred the harder carbons; we finally made them hard enough by treating them in hydro-carbon gas by the Sawyer-Man process (Interference Record). II., 977. **3907.**

The paper carbon burners were perfected within two or three weeks of March 1st, 1878 (Interference Record). II., 979. **3915.**

CARBON:

The denser, harder and more homogeneous the carbon, the more durable the lamp. The most suitable carbon is that produced by the hydro-carbon process; the order of preference being as follows: (*a*) Carbon deposited by electric action; (*b*) The hardest retort carbon; (*c*) The best artificial carbon; (*d*) Hard coke; (*e*) Dense charcoal (charcoal impregnated with syrup and the syrup carbonized); (*f*) Willow, paper and other fine charcoal; (*g*) Ordinary charcoal; (*h*) Graphite. Edison's carbon belongs to class *e* or *f* (Interview published in "New York Tribune," of January 2, 1880). VI., 4176-7.

The denser, harder and more homogeneous the carbon of which the burner is made, the more lasting it will be. These are a part of the elements of success ("Electric Lighting," 1881). VI., 4291.

CARBONIZATION:

At first Mr. Man and I carbonized strips of paper by putting them in a sealed glass globe through which a current of illuminating gas was flowing. Afterwards Mr. Man made a box out of some old pieces of cast iron, in which he packed the strips of paper in powdered gas retort carbon, and carbonized them (Interference Record). II., 973-4. **3892-4.**

CARBONIZATION—(*Continued*):

At Walker Street (to which we moved on the 18th of October, 1878) Mr. Man and I divided our work. Mr. Man experimented with carbons. He continued carbonizing paper and live willow twigs and all kinds of woods. Made some carbons from artist's crayon, called French willow carbon (Interference Record). II., 978-9. **3911-3.**

CLAMPING:

The paper carbons were held to the connecting conductors by clamping the ends; frequently we slit the ends of the conductors, which were sometimes of carbon, sometimes of metal. In some my father made a square cavity, which was packed with powdered carbon after the burner was put in (Interference Record). II., 975-6. **3899-902.**

COMMERCIAL SUCCESS:

Speaking of his lamp having a burner made entirely from carbon deposited by the hydro-carbon process, the author says; "To the necessity of frequent renewals, and the time and skill required to produce the carbons, was due the commercial failure of these lamps ("Electric Lighting," 1881). VI., 4298.

"We may now be supposed to have arrived at an adequate conception of the principles underlying the various forms of incandescent lamps. We have seen that an incandescent carbon, however completely isolated from gases with which it enters into chemical combination, is a destructible mass of matter. We have, perhaps, reached the conclusion that means for its renewal must be provided, and that this renewal must not be frequent, and that it must be cheaply accomplished. The lamp, furthermore, must be cheaply and hermetically sealed and readily recharged with a carbon-preservative atmosphere, or exhausted of atmospheric air. The new Sawyer lamp, exhibited in New York, and at the Franklin Institute in Philadelphia within the past few weeks, is designed to meet the requirements mentioned." Here follows a description of Sawyer's latest feeder lamp, having a separable lamp chamber, which is filled with nitrogen ("Electric Lighting," 1881). VI., 4318 *et seq.*

A lamp, such as I have mentioned as lasting from one second to ten minutes, could not be used in competition with gas or other commercial lights. I do not think that a lamp that would burn from 5 to 100 hours could be used in competition with gas or other commercial lights. Between October 20th, 1878, and January 20th, 1878, we produced an incandescent carbon conductor as capable of competing with gas as any other electric lamp produced with an incandescent paper carbon (Interference Record). II., 986. **3941-3.**

CROSS-SECTION:

"The smaller the section of the pencil (carbon burner), the shorter the life. The larger the section, the more current required. The longer the pencil,

CROSS-SECTION—(*Continued*):

the more current required" (Interview published in "New York Tribune," of January 2, 1880). VI., 4177-8.

Edison's present lamps, with enlarged burners, will not last a week when run at fifteen and a half candles, and his former lamps, more than three hours without disruption of the burner (Letter to "New York Herald," of August 12, 1880). VI., 4254.

"The best artificial carbons for incandescent lighting that we (Sawyer and Man) have obtained are made by the Carré process. * * * Pencils of one thirty-second of an inch in diameter and nine inches in length, made expressly for us, are as absolutely straight and regular as a wire under tension" ("Electric Lighting," 1881). VI., 4292 and 4293.

The burner of the first Sawyer-Man lamp made, which was given publicity, varied from one thirty-second to one-twelfth of an inch in diameter, and was half an inch in length ("Electric Lighting," 1881). VI., 4311.

My former theory was that the best incandescent conductor for an electric light would be one having the highest resistance and least transverse mass. My present theory is that the best incandescent conductor should have not only the least transverse mass, but the least resistance; therefore I would treat the carbon so as to obtain a heavy deposit (Interference Record). II., 984, **3934-5.**

DURABILITY:

Challenges Edison to run his carbonized paper lamp three hours, and says that in a perfect vacuum it will last twenty minutes (Letter to "New York Sun," of December 22, 1879). VI., 4169.

Says that the average life of his own lamps having horseshoe-shaped burners was an hour (Letter to "New York World," of December 24, 1879). VI., 4174.

The denser, harder and more homogeneous the carbon, the tougher it is, and the more durable the lamp (Interview published in "New York Tribune," of January 2, 1880). VI., 4176.

Says that the best carbon of the charcoal order which he made was produced substantially by Gaudoin's process of impregnation and recarbonization, and that pencils of this carbon one-eighth inch in diameter and one-half inch in length, when heated by the current from a dull red to true incandescence, gave a light of from one-half a candle to two hundred and fifty candles. At a dull red heat they lasted from 100 to 200 hours; between a red and white heat 20 hours; at a white heat five hours; and at incandescence from 20 minutes to five minutes, or even less than one minute. The pencils were enclosed in an atmosphere of nitrogen. No consump-

DURABILITY—(*Continued*):

tion took place, but at incandescence rapid disintegration occurred (Interview published in "New York Tribune," of January 2, 1880). VI., 4177.

Again asserts that notwithstanding the reports that one of Edison's lamps has been running 240 hours, it will not give a light of twelve candles and last for more than three hours (Letters to "New York Sun," and to "New York Tribune," of January 5, 1880). VI., 4179-80.

Edison's present lamps with enlarged burners will not last a week when run at fifteen and a half candles, and his former lamps more than three hours without disruption of the burner (Letter to "New York Herald," of August 12, 1880). VI., 4254.

The paper carbon burners, untreated by the Sawyer-Man process, would last from one second to ten minutes, if run to give a good bright light; if run at a low temperature, they would run anywhere from one to five hours. It depends entirely upon the temperature. After being treated they would last, at 25 candles, from 5 to 100 hours, but generally they would fracture in from 5 to 20 hours (Interference Record). II., 977-8, **3907-9.**

One or two of our paper carbon lamps burned about 100 hours. The majority of them would fracture in about five hours. Nineteen-twentieths of them would fracture in about twenty hours. That is, if run up to the temperature that would give about twenty-five candles of light (Interference Record). II., 980, **3943-4.**

EDISON'S LAMP, SAWYER'S OPINION OF:

Edison "is going over the same ground that Bouliguine, Lodyguine, Kosloff, Konn, Starr, King, myself and others have traversed. First, iron; second, platinum; third, carbon in different shapes. * * * I challenge him:

First. To maintain a vacuum in his lamps.

Second. To run his carbonized paper lamp three hours (in practice, in a perfect vacuum, it will last twenty minutes).

* * * * * * * * * * *

Seventh. To prove that with his carbonized paper lamp that he can obtain two lights of ten candles each per horse-power. * * * And I further allege that all Mr. Edison's statements are erroneous, and I offer $100 as a prize for him to prove each and all of the above eight allegations. Let him run one of his lamps three hours and the public will be satisfied that I am correct" (Letter to "New York Sun," of Dec. 22, 1879). VI., 4169.

"The 'Herald' is at perfect liberty to advocate Mr. Edison's claims and I am at perfect liberty to advocate my own. If you care to settle the question of priority of invention upon the horseshoe lamp as between Mr. Edison and myself, you may inspect one of these lamps which broke down at No. 94 Walker Street about a year ago, and, after many experiments, was

EDISON'S LAMP, SAWYER'S OPINION OF—*(Continued)*:

so far condemned that Mr. Man and I concluded we would not waste enough money on it to pay for a patent. This lamp is at present just exactly as it was removed from the bracket, hermetically sealed in a glass globe filled with nitrogen gas and in just exactly the same condition as it was in a year ago. To avoid any question I placed said abandoned institution in the hands of Messrs. Arnoux & Hochhausen, No. 2 Howard Street, yesterday (Monday) morning at nine o'clock. * * * Next week I shall show my system of electric household illumination in this city in practical operation, and if I do not prove it superior to anything else, I am much mistaken, and if I do show to those interested that it is superior, all the personalities in the 'Herald' or by Mr. Edison will not prevent capital putting it where it will do the most good" (Letter to "New York Herald," of Dec. 24, 1879). VI., 4170-1.

" * * * All we have heard from Menlo Park is that Mr. Edison is a great, and eccentric genius who divides his time between eating herring, wearing old hats, rolling tar abstractedly in his fingers, going without his dinner, and finally founding his great achievement upon, as has always really been the case, cotton thread and paper. This does not prove, however, that Mr. Edison may not some day do something. I only allege that up to this time he has done absolutely nothing that is new or valuable in electric lighting, and I am prepared to stake my reputation as an electrician on this statement. * * * Over a year ago I experimented with the horseshoe lamp and found it a failure, even with the carbon much harder and more tenacious than paper carbon. Some dozen of these lamps were constructed. The average life of the horseshoe was one hour. One of these lamps, with the horseshoe complete (except at the point where rupture occurred when the lamp broke down), is still hermetically sealed in its glass tube, and still charged with nitrogen just as it was taken from the bracket in January last. * * * A further fact about the horseshoe lamp is that it is so complete a failure that we decided nearly a year ago it would be wasting money to spend $35 for a patent upon it. * * * He says he proposes to exhibit his light at Menlo Park next week. Next week I shall exhibit my light in New York in practical household use. The public can then judge for itself whether my system is a failure, and whether Mr. Edison has not been either himself deceived or persistently deceiving the community" (Letter to "New York World," of Dec. 24, 1879). VI., 4173-4.

"The public has received from Menlo Park the following positive assertions: (1) That Mr. Edison's new lamp consists of a horseshoe of carbon about two and one-half inches long, clamped in platinum holders and hermetically sealed in a glass globe, from which the air has been exhausted. (2) That the horseshoe, consisting of carbonized bristol-board, is so tough and flexible that it can be twisted nearly half way round without breaking. (3) That the horseshoe of carbon, no oxygen being present in the

EDISON'S LAMP, SAWYER'S OPINION OF—*(Continued)*:

globe, will last an ordinary lifetime; that it has already been run over 100 hours without suffering deterioration. (4) That the light from each lamp is about equal to an ordinary gas jet, or, say, 10 or 12 candles. (5) That no dynamo machine known can generate sufficient electricity to destroy one of Mr. Edison's horseshoes. (6) That the chief point of advantage in the new lamp is its high resistance—140 ohms." "The use of platinum as a holder for the incandescent carbon conductor is fatal to the durability of a lamp. Carbon only of larger sections than the incandescent carbon can be employed."

Mr. Edison's paper carbon is very much larger than mine, "and when a length of incandescent conductor of one-half inch is reached the current can no longer be economically used, because to increase the size is to increase the radiating surface, and the short carbon can be made to give all the light desired, viz., from 25 to 250 candles." As to the kind of carbon which Mr. Edison employs: "The denser, harder and more homogeneous the carbon, the tougher it is, and the more durable the lamp, for the reason that the whole action of the current (that very action which produces light, an intense vibration of the atoms or molecules of the carbon, amounting to several hundred trillions of vibrations per second) is to disrupt and disintegrate the carbon. The carbon formed by the process discovered in my experiments is the only one thus far that offers hope of permanency—a fine pencil of carbon being immersed in olive oil or any hydro-carbon gas or liquid, and electrically heated as in the process of welding before described, whereby it is built up with carbon so hard and homogeneous that it may be polished like jet. As we descend from this we get less durable material, the order of durability being: *(a)* Carbon deposited by electric action; *(b)* the hardest retort carbon; *(c)* the best artificial carbon; *(d)* hard coke; *(e)* Dense charcoal (charcoal impregnated with syrup and the syrup carbonized); *(f)* willow, paper and other fine charcoal; *(g)* ordinary charcoal; *(h)* graphite. Mr. Edison's carbon belongs to the class *e* or *f*, and as carbon in all its forms is extremely brittle, his statement that his paper carbon is so tough and flexible that it can be twisted half way round, &c., without breaking, is open to criticism." As to the question of durability: "The best carbons of the charcoal order we have produced by impregnating with syrup the finest French willow charcoal, used by artists, and carbonizing the same, repeating this process a sufficient number of times. This is substantially the process of Peyret and of Gauduin. In pencils of $\frac{1}{8}$ inch diameter and $\frac{1}{2}$ inch length, with perfect carbon connections and in an atmosphere of pure nitrogen, not even the $\frac{1}{1000000}$ of oxygen being present, these carbons will last as follows under the action of the electric current: *(a)* At a red heat, giving a light of perhaps $\frac{1}{2}$ of a candle, 100 to 200 hours; *(b)* at between a red and a white heat, giving a light of 1 or 2 candles, 20 hours; *(c)* at a white heat, light 4 candles, 5 hours; *(d)* at true carbon incandescence, when the pencil has the limpid appearance of the sun and gives a light of 25 or 30 to 250 candles, 20 to 5 minutes, or even less than one minute, disintegration then occurring, but no consumption taking place. The smaller the section of the pencil the shorter its life. The

EDISON'S LAMP, SAWYER'S OPINION OF—(*Continued*):

larger the section the more current required. The longer the pencil the more current required." As to the liability of Edison's horseshoe carbons being injured by an accidental and sudden increase in the strength of the current: "When a carbon is in a high state of incandescence, double the current invariably ruptures or disintegrates the carbon. * * * Experience has demonstrated that, within reasonable bounds, the less the resistance of an electrical circuit which includes the resistance of the wires of the machine and that of the lamps outside of it, the less the power required for effective work. The arrangement of Mr. Edison's lamps in multiple circuit, so as to lessen the external resistance where a large number of lamps are to be run, is hazardous. In running 2,500 lamps by a single generator the means will be found in a square of fifty in a series and fifty in multiple. This would make the external resistance of Mr. Edison's circuit 140 O., requiring an intensity of current that would give violent shocks to those who might, by accident, touch the conductors, and a most costly insulation of the main wires. To place less lamps in series and more in multiple is as hazardous as to go the other way, inasmuch as it would increase the chances of a short circuit extinguishing lamps in other series. No lamp can be practical unless of low resistance" (Interview published in "New York Tribune," of January 2, 1880). VI., 4175-8.

"Notwithstanding the assertion that one of Mr. Edison's electric lamps has been running 240 hours, I still assert, and am prepared to back up my assertion, that Mr. Edison cannot run one of his lamps up to the light of a single gas jet (to be more definite, let us call it twelve candle-power) for more than three hours." (Letters to "New York Sun," and to "New York Herald," of January 5, 1880). VI., 4179-80.

"It is stated that the average power of the Edison lamp is fifteen and a half candles, and certain professional gentlemen have accorded ten separate lamps per horse-power, each of a power of twelve candles, or an average in divided light of 120 candles per horse-power. This is a serious error, on account of which the aforesaid professional gentlemen are entitled to our profoundest sympathies. If one of them were to tell a steamboater that it is as cheap to run a boat ten miles an hour as five he would be laughed at; but these great intellects experience no misgivings whatever in informing the public that it takes as little power to overcome an electrical resistance of 150 ohms (as in Professor Edison's lamp) as it does to overcome a resistance of one or one-half or one-quarter ohm. What renders the voltaic arc lamp and generator of one electrician more powerful (and therefore cheaper, since the expenditure of steam power is the same in both cases) than the lamp and generator of another? It is the low resistance of his arc and generator.

Why is a Maxim or a Hochhausen or a Siemens arc more powerful with the same expenditure of steam power than that of others? Because their

EDISON'S LAMP, SAWYER'S OPINION OF—(*Continued*):

arcs are, so to speak, 'short and thick,'" of great quantity and low tension, while the failures are found in lamps of high resistance. * * * Owing to the high internal resistance of his lamps and the incapability of the horseshoe fiber to stand powerful currents, Professor Edison has never been able to operate more than two of his lamps at twelve candle-power each per horse-power, and it is said that he cannot so operate them to-day and he is asserted to be unwilling to submit the same to a test before competent engineers. Professor Edison claims a life of six months ordinary use for each of his lamps run at a power of fifteen and a half candles. This is so great an error in calculation that his present lamps, provided with enlarged carbons, will not run a week at that power, and his former lamps more than three hours without disruption of the fibre" (Letter to "New York Herald," of August 12, 1880). VI., 4252-4.

EFFICIENCY:

Does not believe that Edison can obtain two lights of ten candles each per horse-power (Letter to "New York Sun," of December 22, 1879). VI., 4169.

FLEXIBILITY:

As carbon in all its forms is extremely brittle, Mr. Edison's statement, that his paper carbon is so tough and flexible that it can be twisted half way round without breaking, is open to criticism (Interview published in "New York Tribune," of January 2, 1880). VI., 4177.

"The hardness and brittleness of glass and homogeneous carbon at ordinary temperatures are substantially alike. Glass, drawn into fine threads, and carbon in filaments, may be bent, and to a certain extent twisted, without breaking" ("Electric Lighting," 1881). VI., 4300.

HYDRO-CARBON TREATMENT:

In 1878, after the paper carbons were made, I treated them electrically in the presence of hydro-carbon for the purpose of consolidating and enlarging them (Interference Record). II., 974. **3895-6.**

The Sawyer-Man paper carbon conductors, after being treated by the hydro-carbon treatment, would last from 5 to 100 hours run at 25 candles, but they would generally fracture in from 5 to 20 hours, if run at that power (Interference Record). II., 977-8. **3908-9.**

There were two different effects produced upon the carbons by the hydro-carbon treatment. In some cases the whole mass of the original carbon would be hardened and become homogeneous. In other cases the original carbon would remain unchanged, and the deposit carbon could, perhaps, be broken off from it. If the original carbon is heated up so as to drive out occluded gases, but not sufficient to decompose the hydro-

HYDRO-CARBON TREATMENT—(*Continued*):

carbon surrounding it, its pores will become permeated by the hydro-carbon, which a quick impulse of current will decompose in the mass of the carbon, thus hardening it, and so on. But if the carbon is heated so hot as to decompose the surrounding hydro-carbon in the first place, then the original carbon will remain unchanged. By combining the two processes the original and deposit carbon may be made one and substantially the same. The effect upon the carbons is to reduce the resistance in proportion to the extent of the treatment (Interference Record). II., 983-4. **3931-3.**

INVENTION INVOLVED:

The day after the announcement, in the "New York Herald," of Mr. Edison's discovery, I took one of our paper carbon lamps to Mr. Arnoux to hand to the editor of the "Tribune," to show that we had previously invented that lamp. It might have been as early as in December, 1878 (Interference Record). II., 976-7. **3904-5.**

LAMP, INCANDESCENT:

Lodyguine's lamp "was the most practical and most studied of all that had preceded it, for Lodyguine recognized the value of a perfect connection with the incandescent portion, such as results from enlargement of the carbon at the points of contact with conductors leading to it, and he provided for the inevitable destruction of the rod by arranging another to take its place." This latter feature of Lodyguine's lamp is also present in the lamp designed by Fontaine ("Electric Lighting," 1881). VI., 4286 and 4290.

LENGTH:

Mr. Edison's paper carbon is very much longer than mine, "and when a length of incandescent conductor of one-half inch is reached the current can no longer be economically used, because to increase the size is to increase the radiating surface, and the short carbon can be made to give all the light desired, viz., from 25 to 250 candles" (Interview published in "New York Tribune," of January 2, 1880). VI., 4176.

RESISTANCE:

"Experience has demonstrated that within reasonable bounds the less the resistance of an electrical circuit which includes the resistance of the wires of the machine and that of the lamps outside of it, the less power required for effective work. * * * No lamps can be practical unless of low resistance" (Interview published in "New York Tribune," of January 2, 1880). VI., 4178.

"* * * Certain professional gentlemen have accorded ten separate (Edison) lamps per horse-power, each of a power of twelve candles or an average in divided light of 120 candles per horse-power. This is a serious error. * * * These great intellects experience no misgivings whatever in

RESISTANCE—(*Continued*):

informing the public that it takes as little power to overcome an electrical resistance of 150 ohms (as in Professor Edison's lamps) as it does to overcome a resistance of one or one-half or one-quarter ohm. What renders the voltaic arc lamp and generator of one electrician more powerful (and therefore cheaper, since the expenditure of steam power is the same in both cases) than the lamp and generator of another? It is the low resistance of his arc and generator." (Note. The arc light is of low resistance, but, contrary to the writer's statement, the arc dynamo is of high resistance. On the other hand, the incandescent light is of high resistance, and its dynamo of low resistance). Says the Maxim, Hochhausen and Siemens arc lamps are more powerful than others, with same expenditure of power, because "their arcs are 'short and thick,' of great quantity and low tension, while the failures are found in lamps of high resistance. Owing to the high internal resistance of his lamps and the incompatibility of the horseshoe fiber to stand powerful currents, Professor Edison has never been able to operate more than two of his lamps at twelve candle-power each per horse-power * * *" (Letter to "New York Herald," of August 12, 1880). VI., 4252-4.

In 1878 I had a theory that the most perfect incandescent lamp would be one having the highest resistance and the least transverse mass, and I filed an application in the Patent Office for a chalk, or some similar material, held between two conductors and containing in a little groove, running from conductor to conductor, a powdered graphite or carbons to carry out this idea (Interference Record). II., 972-3, **3888-9.**

The hydro-carbon treatment reduces the resistance of the carbon conductors in proportion to the extent of the treatment (Interference Record). II., 984, **3933.**

My theory that the most perfect electric lamp would be the one in which the incandescent conductor had the highest resistance and the least transverse mass was gradually abandoned by me. My present theory is that the most perfect electric lamp is one in which the incandescent conductor has not only the least transverse mass, but the least resistance. I soon began to reduce the resistance of my carbons to as low as an ohm; at present I make them only quarter of an ohm. Therefore I would treat the carbons so as to obtain a thick deposit. Mr. Man reduced the resistance in his carbons from fifty to seventy-five per cent. by the hydro-carbon treatment (Interference Record). II., 984, **3934-5.**

SAWYER'S FEEDER LAMP:

It being only a question of a brief period of time when a carbon loop or pencil will suffer disintegration, it is clear that some means of renewing the burner must be provided without destroying the lamp. To replace a Sawyer-Man (arch-shaped) carbon required two or three hours, and the recharging of the lamps with nitrogen costs about seventy cents. It is, therefore, an impracticable lamp, and to obviate frequent renewals the first

SAWYER'S FEEDER LAMP—(*Continued*):

Sawyer feeding lamp was devised. Thus a very durable apparatus was obtained, but by no means a successful one ("Electric Lighting," 1881). VI., 4315.

SAWYER-MAN LAMP:

"Over a year ago I experimented with the horseshoe lamp and found it a failure, even with the carbon much harder and more tenacious than paper carbon. Some dozen of these lamps were constructed" (Letter to "New York World," of Dec. 24, 1879). VI., 4173.

"In all the time that I have been working at this problem of electric lighting I have been working simply and solely with a view to a genuine, scientific success. I have made no money out of it. Instead of selling out I have increased my original interest by $19,000; have bought my own stock from those to whom I made a gift of it at 50 per cent. of its par value. I think I know enough about this business not to make a very great mistake and not risking my reputation by any wild challenges" (Letter to "New York Herald," of January 6, 1880). VI., 4181.

History of the development of the Sawyer-Man lamp ("Electric Lighting," 1881). VI., 4310-30.

SAWYER-MAN WORKSHOP:

At Centre Street we had no facilities for carbonizing, there being neither a stove nor a furnace there. At Howard Street we had no facilities for experiments on lamps. At Centre Street we used the dynamo in the engine room of Arnoux & Hochhausen. I had a Hochhausen electro-plating machine which I bought, and another Hochhausen machine which I borrowed, like the plating machine, but wound with fine wires. Then two or three Weston machines were sent to us to try, but we could do nothing with them. We had only one workman at Centre Street, my father (Interference Record). II., 974-81, **3893-3922.**

SEALING:

"Next to preserving the carbon from chemical change, the greatest difficulty is found in hermetically sealing the globe of the lamp. The sealing of glass upon platinum is familiarly known in Geissler vacuo-tubes; and while the degree of skill required for this method of sealing is rare, the Geissler method is undoubtedly as perfect as any yet devised" ("Electric Lighting," 1881). VI., 4304-5.

SHAPING:

Almost all the carbons for use in our lamps were reduced to form before the paper was carbonized. When we wanted to expose the broadside to the light we had to cut them out before, but when exposed sidewise we could bend them after they were carbonized (Interference Record). II., 974-5, **3896-7.**

STABILITY:

"The denser, harder and more homogeneous the carbon the tougher it is, and the more durable the lamp, for the reason that the whole action of the current (that very action which produces light, an intense vibration of the atoms or molecules of the carbon, amounting to several hundred trillions of vibrations per second) is to disrupt and disintegrate the carbon. The carbon formed by the process discovered in my experiments is the only one thus far that offers hope of permanency." This is the hydro-carbon process (Interview published in "New York Tribune," of January 2, 1880). VI., 4176-7.

VACUUM:

Does not believe that Edison can maintain a vacuum in his lamps (Letter to "New York Sun," of December 22, 1879). VI., 4169.

SCHWENDLER, Louis:

Electrician of Government Telegraphs in India.

LAMP, INCANDESCENT:

"Unless we shall be fortunate enough to discover a conductor of electricity with a much higher melting point than platinum, and the specific weight and specific heat of which conductor is also much lower than for platinum, and which, at the same time, does not combine at high temperatures with oxygen, we can scarcely expect that the principle of incandescence will be made use of for practical illumination" ("Telegraphic Journal," for 1879). III., 1825, **7299.**

SUBDIVISION:

"If more than one light is produced in the same circuit by the same current the external or available light becomes rapidly dearer with the increase of the number of lights produced. For this reason already, if not for many others, the *division of light* must result in an engineering failure. It is in the nature of the electric light that it should be used in *great intensity* in *one point* instead of small intensities in many points" ("Journal of the Asiatic Society of Bengal," for March, 1879). III., 1816, **7264.**

After criticising Preece's paper on subdivision, Schwendler says that the mathematical formulæ of Preece will show that subdivision is possible, if it be assumed that, as lamps are added to the circuit in multiple arc, the resistance of the individual lamps is increased so as to keep the combined resistance constant. He ignores altogether the vital question of radiating surface. His conclusion is that "inventors should not, therefore, be downhearted. On the other hand, investors in gas need not hasten to get rid of their shares, for there are many questions involving practical difficulties which still remain to be solved * * *" ("Journal of the Asiatic Society of Bengal," for March, 1879). III., 1817-8, **7268-70.**

Referring to his own experiments the writer says: "Experiments, however, show that this is not the case, *i. e.*, the sum of the measured intensities of *two* smaller lights is perceptibly smaller than the measured intensity of *one* large light, and that this difference becomes larger and larger as we increase the number of lights produced by the same current, *i. e.*, by the same E. M. F. (electro-motive force) with the same total resistance in circuit. * * * That the *measured intensity* of *one* light is invariably greater than the sum of the measured intensities of *n* lights, is an undoubted fact, proved by many experiments very conclusively. * * * If we produce *two* arcs it will be seen *at once* that the sum of the losses must be greater than the losses in *one* arc. This constitutes one of the reasons why the division of the electric light becomes less and less economical with the increase in the number of lights, and that soon a practical limit shall be reached for the division" ("Journal of the Asiatic Society of Bengal," for March, 1879). III., 1821-2, **7283-6.**

SCIENTIFIC PERIODICALS.

BURNER OF CARBON:

Alluding to the Edison lamp described in the "New York Herald:" "The only difference between these lamps (King's and Lodyguine's) and that now brought forward, is, that Edison prefers a different and apparently less durable kind of prepared carbon to that employed by his predecessors, though, again, in the employment of carbonized paper he has been more than once anticipated" (Editorial in "Nature" for January 2, 1880). VI., 4206.

DISCOVERY:

"Almost the whole civilized world appears to be waiting with feverish anxiety for full details and confirmation of Prof. Edison's latest discovery in electric lighting. If he has indeed arrived at the solution claimed, and has produced a domestic light free from the disadvantages hitherto attendant on electric illumination and those which are inseparable from gas; a light at the same time cheap in production, entirely under control, capable of regulation and requiring no special management, it is certain that for the first time since the problem of electric lighting has been studied that gas has found a dangerous rival" (Editorial in "Engineering" for January 9, 1880). VI., 4190.

EVAPORATION:

In an article upon "The Brush Electric Light," Edison's carbon lamp is referred to and it is stated, concerning the same, that "we can, of course, understand how a slip of carbonized paper can be made to produce an excellent electric light in this way; but until further experience has shown that the slip will endure without disintegrating, it would be premature to congratulate Mr. Edison on his undoubted success" (Article in "Engineering" for January 2, 1880). VI., 4189.

After giving a description of Edison's carbon lamp, as detailed in the "New York Herald," and alluding to Upton's "Scribner's Magazine" article as confirming the same, the statement is made that "we fear Mr. Edison is thirty-five years behind the time in his new invention. The patent roll of Great Britain from 1845 contains the specification of a lamp invented by King, in which a thin rod of carbon was placed in an exhausted globe; and the inventor specially dwells on the advantage of a Torricellian vacuum for the purpose. A similar lamp was designed by Lodyguine in 1873. The only difference between these lamps and that now brought forward is that Edison prefers a different and apparently less durable kind of prepared carbon to that employed by his predecessors, though, again, in the employment of carbonized paper he has been more than once anticipated." After alluding to some of Edison's

EVAPORATION—(*Continued*):

early experiments, the article continues: "A carbon filament prepared from charred paper, as described, was adopted. It will be difficult to convince us that the fragile horseshoe paper cinder will resist disintegration better than the carbon used in exhausted tubes by dozens of other experimenters; indeed, the invention is avowedly so recent that no lamp can have been tried for a period long enough to warrant an assertion of its permanence. The latest telegrams from the States inform us that Edison finds great difficulty in maintaining good vacua, and that further experiments are necessary. It must not be forgotten that even in a globe exhausted to one-millionth of an atmosphere there yet remain many millions of millions of molecules of air enough to make the disintegration of the incandescent carbon fiber only a question of time." After alluding, among other things, to Edison's dynamo, the article reads: "Whether the latest forms of invention are doomed to the fate of their predecessors or not, the man who can struggle against failures and discouragements as indomitably as Edison has done deserves to succeed, however erratic his methods. * * *" (Editorial in "Nature" for February 12, 1880). VI., 4205-10.

FILAMENT OF CARBON:

Alluding to the Edison lamp, described in the "New York Herald:" "A carbon filament prepared from charred paper, as described, was adopted. It will be difficult to convince us that the fragile horseshoe paper cinder will resist disintegration better than the carbon used in exhausted tubes by dozens of other experimenters; * * *" (Editorial in "Nature" for January 2, 1880). VI., 4207.

RESISTANCE:

Commenting upon Upton's "Scribner's Magazine" article: "Either, as we have said, Mr. Edison and Mr. Upton know little or nothing of electric lighting or else they have put forward statements which are in advance of facts, and that knowingly and of set purpose. * * * But he understands so little the questions involved in the production of the electric light that he has failed to see the consequences which must ensue from the fact that, if the resistance be increased, the power must be increased also" (Article in "Engineering" for February 13, 1880. VI., 4211.

STABILITY:

In an article upon "The Brush Electric Light," the new Edison lamp is spoken of as having a carbonized paper horseshoe burner placed in a globe, which is exhausted to the one-millionth of an atmosphere. Apparently the writer does not know whether there is an advantage in having a high vacuum to render the burner stable, as he says: "We can, of course, understand how a slip of carbonized paper can be made to produce an excellent electric light in this way; but, until further experience has shown that the slip will endure without disintegration, it would be premature to congratulate Mr. Edison on his undoubted success" (Article in "Engineering" for January 2, 1880). VI., 4188-9.

SUBDIVISION:

"It is true that at present an invention, by which the electric current supplying the electric lamps can be subdivided so as to feed a great many light centres and thus at the same time moderate while it distributes the light, is a desideratum necessary to the complete success of electric lighting, even for general street purposes, let alone household uses. But tried inventors are at work on the problem, and any day may see its accomplishment" (Editorial in "Telegraphic Journal" for October 15, 1878). VI., 4039.

"Whether Mr. Edison's system of utilizing electric currents for the production of light can compare favorably with other systems can only be satisfactorily demonstrated by actual experiment and experience. It will be severely handicapped against all electric arc systems by the physical drawback common to all incandescent systems, namely, that for each addition to the number of lights in circuit an enormous reduction is made in the intensity of the light produced. We, therefore, cannot but believe that we have not yet seen the system by which Mr. Edison states, in his most recent letters to this country, that he is able to place 678 electric lamps in one circuit" (Editorial in "Engineering" for February 21, 1879). VI., 4095.

"Electricians who were not commercially interested in any form of electric lamp or machine showed that this subdivision could only be effected at an enormous expense for light and material, owing to causes which we need not stop to explain. Again, very thick conductors are essential to any success in subdividing the electric light. * * * If thin conductors are used the loss of light is enormous, and this truth Mr. Edison has apparently only just discovered, for he admits that under his system it will be impossible to obtain more than one-tenth of the light which could be had with a given power and moderate subdivision. * * * Before the electric light could be subdivided with facility and economy, the operation of some new law must be discovered, and this we hold to be extremely improbable" (Editorial in "The Engineer" for January 10, 1879). VI., 4095-6.

In reference to Edison's platinum lamp: "With all its defects for domestic purposes, still Mr. Edison's lamp might perhaps be used to much advantage for street lighting, and in factories or theatres; in fact, in any situation where it could be looked after by a skilled attendant. If the current can be successfully divided among dozens of such lamps, then may gas-makers quake; but nothing of the kind can be done" (Editorial in "The Engineer" for February 14, 1879). VI., 4096.

An article upon Edison's French patent, condemnatory of his platinum lamp as being of no use, among other things, states that: "We are forced to say that, from a theoretical point of view, the apparatuses contrived by Mr. Edison are far from being absurd; the patent contains some ingenious details and some very original contrivances; but, from a practical

4

SCIENTIFIC PERIODICALS.

SUBDIVISION—(*Continued*):

standpoint, the only thing of interest to holders of gas stock is commonplace, childish, or impossible to realize. * * * However, we believe that the experiments which are being carried on in the laboratory at Menlo Park will be heard from and that they will give birth to some more practical ideas." After calling attention to some features in the patent which are old, the article continues: "Decidedly, the holders of gas stock can sleep tranquilly. The invention which is going to destroy the value of their shares is not yet conceived" ("La Lumiere Electrique" for May 15, 1879; article taken from "Revue Industrielle"). VI., 4107-8.

In an article upon "The Brush Electric Light," it is stated that "more than a year has passed by since the scientific world was startled and a panic struck into the breasts of gas shareholders by the cablegram announcing that Mr. Edison had solved the problem of the divisibility of the electric light and that he would speedily supply such lights into all households at a cost far below that of gas. Enthusiasts in his rare inventive faculty were disposed to believe this announcement, but more prudent critics threw doubts on its reliability; and, as time went on without bringing with it the promised lamp, the public at large began to be sceptical of the alleged discovery, and all the sanguine confidence of Mr. Edison himself and the highly-colored reports of Yankee correspondents could not shake the opinion which gradually gained ground that he had discounted success." The article then alludes to Edison's tempering of metals in a high vacuum, so that they may withstand a high temperature without fusion, and then states that "the great advantage of the incandescent mode over the arc is that it yields a softer and steadier light; in fact, a light as nearly perfect as any light need be. But this advantage is more than counterbalanced by the extra cost of production. Mr. Edison, it is understood, has at last approached very near to, if, indeed, he has not achieved, a complete success." It is then stated that this new lamp has a carbonized paper horseshoe burner contained in a glass globe, which is exhausted to one-millionth of an atmosphere, and, after a résumé of some of its alleged advantages, that "we can, of course, understand how a slip of carbonized paper can be made to produce an excellent electric light in this way; but until further experience has shown that the slip will endure without disintegrating it would be premature to congratulate Mr. Edison on his undoubted success" (Article in "Engineering" for January 2, 1880). VI., 4187-9.

"Mr. Edison has once more come forward with an electric lamp which we are assured solves the problem of the economic subdivision of the electric light. We have heard this statement so many times with respect to one form or other of lamp devised by this most ingenious and indefatigable inventor, each of which in turn has come to no tangible result, that it becomes harder than ever to trust to the rash announcements furnished so airily by the newspaper press on both sides of the Atlantic" (Editorial in "Nature" for February 12, 1880). VI., 4205).

SHALLENBERGER, Oliver B.

states that he is chief electrician of the Westinghouse Electric Company, and has held that position since its organization. III., 1375, **5499.**

BURNER OF CARBON:

Resistance of the burner when cold is about double what it is when hot. III., 1376, **5502.**

Those made by the Westinghouse Company are subjected to the hydro-carbon treatment, whereby the specific resistance of the carbon is reduced from one-fourth to two-thirds the specific resistance of the original carbon. III., 1376-7, **5504-7.**

of lamps most generally manufactured in late years are made from bamboo, silk thread, cotton thread, paper and tamadine. III., 1380, **5520.**

The burners of commercial lamps made by the Westinghouse Company vary in diameter from .0055 to .018 of an inch in diameter. III., 1415, **5658.**

Sawyer-Man Patent No. 211,262 contains no reference to use of a burner of vegetable carbon, or to the subjecting of such carbon to hydro-carbon treatment or electrical heating to drive out occluded gases (McKeesport suit). III., 1430, **5719.**

Some of the burners in Shallenberger's Sawyer-Man lamps were made from carbonized bristol board (McKeesport suit). III., 1436, **5742.**

The outer edge of burner in drawing in Sawyer-Man Patent No. 317,676 is one-third longer than its inner edge (McKeesport suit). III., 1452, **5805.**

made from blotting paper would not be useful unless subjected to hydro-carbon treatment. When so treated it makes a good burner for lamps of low resistance. (McKeesport suit). III., 1459, **5836.**

The largest burner made by Westinghouse Company is the 75 candle-power burner. It is .0139 of an inch in diameter and 10.91 inches long. III., 1467, **5867,** and 1483, **5929.**

CANDLE-POWER:

of burners in commercial lamps made by Westinghouse Company varies from 10 to 75 candles. A lamp of 150 candle-power is made which contains two 75 candle-power burners. These lamps require an electro-motive force of 50 to 100 volts. III., 1415, **5658.**

SHALLENBERGER, Oliver B.

CANDLE POWER—(*Continued*):

The vast majority of lamps used in central station lighting give a light about equal to a gas-jet. III., 1419, **5676.**

It is not profitable to go beyond a certain degree of incandescence, because it materially shortens the life of the burner (McKeesport suit). III., 1446, **5781.**

Shallenberger's Sawyer-Man Lamp No. 1 was run at 10 candle-power and required 14.5 volts, 7.3 amperes, and 105.8 watts, or 10.58 watts per candle-power. Lamp No. 7 was run at one and one-half candles and No. 8 at twenty candles (McKeesport Suit). III., 1459, **5833-4.**

CARBON:

of burners of lamps most generally made in late years is made from bamboo, silk thread, cotton thread, paper and tamadine. III., 1380, **5520.**

CLAMPING:

In Defendants' Exhibits Shallenberger Lamps the carbon burners were joined to the leading wires, by mounting the carbons in tubular ends formed on the platinum wires, and then passing a strong current through the joint while immersed in a hydro-carbon liquid. The current heated the joint to redness, and caused a deposit of carbon to be formed upon it, thus cementing the burner and platinum wire together. First knew of this method of making a joint in 1884, and does not know that it was known to the art prior to date of patent in suit. III., 1413, **5650**, and 1414, **5655.**

CLAMPS:

Candle-power of Defendant's Exhibits Shallenberger Lamps, in the case of the largest carbons, was governed by the appearance of the joint with the platinum leading wires. It was deemed advisable not to heat the joints or leading wires too highly. To raise the carbon to too high a temperature might heat the joint sufficient to endanger its continuity and thus destroy the lamp. This was guarded against. III., 1409, **5684-6.**

The heat developed at clamps varies as the resistance of the contact between the clamps and burner, and as the square of the current (McKeesport suit). III., 1443, **5770-1.**

Increasing the length of a burner, the total candle-power remaining unchanged, or diminishing its cross-section without altering the illuminating power per unit of surface, results in a reduction of the amount of heating at the clamps (McKeesport suit). III., 1445, **5777-80.**

The short carbons of series lamps, like those in the Bernstein lamp, lose more heat by radiation from the clamps than the long-carbon lamps (McKeesport suit). III., 1446, **5784.**

SHALLENBERGER, Oliver B.

CLAMPS—(*Continued*):

Heating of clamps by conduction from the burners will be greatest with those of large section (McKeesport suit). III., 1458, **5830.**

CROSS-SECTION:

Thomson-Houston series lamps are of sufficiently low resistance to make them suitable for current of 9 or 10 amperes or more, and are therefore of comparatively large cross-section and short length. III., 1388, **5552.**

Burners in commercial lamps made by Westinghouse Company vary in diameter from .0055 to .018 of an inch in diameter. III., 1415, **5658.**

Diminishing the cross-section of a burner without altering the illuminating power per unit of surface results in a reduction of the amount of heating at the clamps (McKeesport suit). III., 1445, **5780.**

A fine, filamentary carbon burner has the advantage over a short, thick burner in that the resistance through various parts of its cross-section is not so liable to vary. Points of lowest resistance will conduct the most current and become hottest, a result which is detrimental to the life of the burner (McKeesport suit). III., 1447-8, **5786-9.**

Current required varies nearly in proportion to diameter and not to cross-section of burner. III., 1456, **5821.**

Heating of clamps by conduction from the burners will be greatest with those of large cross-section (McKeesport suit). III., 1458, **5830.**

CURRENT:

With same candle-power and efficiency, the longer a burner is made the smaller is the current required to operate it (McKeesport suit). III., 1455, **5820.** Note: Under the conditions above given the radiating surface must remain constant and the diameter must be diminished in direct proportion to the increase in length.

required varies nearly in proportion to diameter of burner (McKeesport suit). III., 1456, **5821.**

DISTRIBUTION OF ELECTRICITY:

The laws governing the distribution of electrical energy in circuits were well known long prior to 1878. III., 1389, **5555.**

by a multiple arc arrangement of lamps in circuit was known to the art prior to 1880 and is very largely used to-day for working a large number of lamps located in the same building; that is, in what is known as an isolated plant. Lamps having the same resistance as Defendants' M and Zigzag Paper Lamps (40 and 80 ohms when hot) are used to a considerable extent in such plants. III., 1416, **5663-4.**

DISTRIBUTION OF ELECTRICITY—(*Continued*):

The advantage of using a carbon burner of great length, as compared with its diameter, consists in the fact that with the lamps in multiple arc a high electro-motive force may be used, which makes the distribution of the current possible without too great cost for conductors (McKeesport suit). III., 1444, **5776.**

In a multiple arc arrangement of circuits, the lamps are connected directly to the two main conductors, and each lamp is independent of every other lamp. In a multiple series arrangement, two or more lamps are connected in series with each other, and these series groups of lamps are connected to the two main conductors. The multiple series system is not equivalent to a multiple arc system or equally available for central station lighting, as in the former system the interruption of any lamp of a group extinguishes the other lamps of that group. To overcome this difficulty, additional appliances are required, which render such system complicated and impracticable. Multiple series systems of distribution have never been largely introduced. III., 1477-8, **5908-9.**

The effect of the alternating current transformer system is to bring the source of low electro-motive force closer to the lamps. With such a system the lamps are connected in multiple arc. With system used by Westinghouse Company the lamps require an electro-motive force of 50 volts. The transformers vary in capacity from 10 to 40 lights, and sometimes are connected in multiple arc to one circuit, so that 200 or 300 lamps may be operated in multiple arc on the same. In such a case the size and cost of the conductors running from the transformer to the lamps is the same as if a dynamo were substituted for the transformer and located at the same place. III., 1478-9, **5910-16.**

Electric lighting from large central stations by means of continuous current apparatus was carried on with commercial success prior to the introduction of the alternating current system of distribution in fall of 1886, and such stations are still in commercially successful operation. III., 1480, **5917-8.**

Does not know the relative number of lamps operated to-day from Edison central stations by continuous current system as compared with the number operated by Westinghouse alternating current system, but thinks it likely that the former class of plants operate a larger number of lamps than the latter, as the Edison Company installed several large plants before the Westinghouse Company began to introduce its system. Thinks the average distance of the lamps from the central station is greater in Westinghouse than in Edison plants. III., 1481-2, **5919-21.**

Multiple series system requires the substitution of an equivalent resistance in place of a lamp when the latter is to be extinguished, resulting in this disadvantage, that the same amount of energy is required, whether the lamps are in use or not. This system is only useful when circumstances require a practically constant number of lamps to be in use, as in street lighting. Such systems have been used in a limited way, but no companies are regularly instaling them. The multiple series arrangement of resistances and other electrical appliances was well understood in 1878, and it would likewise have been understood that electric lamps could be arranged in multiple series without changes in the lamps themselves. III., 1481-2, **5921-7.**

DISTRIBUTION OF ELECTRICITY—(*Continued*):

DURABILITY:

The durability of a lamp is affected by the electro-motive force at which it is operated. III., 1477, **5908.**

EFFICIENCY:

Since Shallenberger's Sawyer-Man lamps were made and tested for purposes of McKeesport suit, they have not been tested to ascertain whether their efficiency has remained unchanged. III., 1467, **5866.**

ELASTICITY AND FLEXIBILITY:

Flexibility of the carbons of Defendant's Exhibits Shallenberger Lamps, which are from .055 to .060 of an inch in diameter, is a little greater than that of Carré carbon. III., 1388, **5551.**

ELECTRO-MOTIVE FORCE:

Shallenberger's Sawyer-Man lamps require an electro-motive force of 12 to 30 volts, or about an average of 20 volts. These lamps, or lamps of similar resistance (requiring the same electro-motive force), would be practically adapted for use in multiple arc. The electro-motive force now used by the Edison Company (referring to simple multiple arc circuits) is not as low as could be practically used for any commercial purposes (McKeesport suit). III., 1451, **5804.**

required by lamps, used with transformer system of Westinghouse Company, is 50 volts. III., 1478, **5991.**

FILAMENT:

All commercial lamps of to-day, which are intended for use in multiple arc, have burners of great length compared with their diameter, so that they assume the filamentary character (McKeesport suit). III., 1444, **5773.**

FILAMENT OF CARBON:

Carbon burners of lamps most generally manufactured in late years are made from bamboo, silk thread, cotton thread, paper and tamadine. III., 1380, **5520.**

FILAMENT OF CARBON—(*Continued*):

The advantage of using a carbon burner of great length as compared with its diameter consists in the fact that, with the lamps in multiple arc, a high electro-motive force may be used which makes the distribution of the current possible without too great cost for conductors (McKeesport suit). III., 1444, **5776.**

A fine filamentary burner has the advantage over a short thick burner in that the resistance through various parts of its cross-section is not so liable to vary. Points of lowest resistance will conduct the most current and become hottest, a result which is detrimental to the life of the burner (McKeesport suit). III., 1447-8, **5786-9.**

In long, thin burners, bent into an arch form, the difference in the length of the outer and inner edges of the burner is inappreciable. The shorter and thicker an arch-shaped burner is the greater is this difference, resulting in more current flowing along the inner edge and greater heating there than along the outer edge. This irregular distribution of heat is detrimental to life of burner (McKeesport suit). III., 1448-9, **5790-3.**

Current required varies nearly in proportion to diameter of burner (McKeesport suit). III., 1456, **5821.**

Nearly all the lamps now made by the Sawyer-Man Company are all slender or filament carbon lamps (McKeesport suit). III,, 1464, **5856.**

The largest burner made by Westinghouse Company is the 75 candle-power burner. It is .0139 of an inch in diameter and 10.91 inches long. III., 1467, **5867,** and 1483, **5929.**

HEATING DURING EXHAUSTION:

Defendant's Exhibits Shallenberger Lamps, were electrically heated during exhaustion in the usual manner as applied to commercial lamps. The process of exhaustion was not completed until the burners had been heated far above their normal incandescence. Most of these lamps were left on the pumps considerably over an hour and a half because they are of unusual types, with unusually large carbons as compared with the ordinary lamps, which require about half an hour for exhaustion. III., 1405-7, **5618-26.**

was a process known to the art prior to date of filing the application of patent in suit. III., 1413, **5649.**

Burners of Shallenberger's Sawyer-Man lamps were heated by the current sometimes in an atmosphere of nitrogen, and at other times in vacuo. Consulted Sawyer-Man Patent No. 211,262 of January, 1879, for this method of treatment. The method pursued was more like than unlike the present method pursued by Westinghouse Company in making commercial lamps (McKeesport suit). III., 1426-7, **5702-5.**

HEATING DURING EXHAUSTION—(*Continued*):

Sawyer-Man Patent No. 211,262 contains no reference to use or treatment of a vegetable carbon (McKeesport suit). III., 1430, **5719.**

Sawyer-Man Patent No. 317,676 describes the process of driving occluded gases out of the burner. Thinks it immaterial whether this description relates to the carrying out of the process in the presence of a nitrogen gas or in vacuo (McKeesport suit.) III., 1461, **5842.**

HYDRO-CARBON TREATMENT:

All the burners of lamps made by Westinghouse Company are subjected to this treatment. III., 1376, **5503.**

Explains the process as carried on by Westinghouse Company and says that it results in a consolidation of the carbon by filling its pores. This results in a marked reduction of its specific resistance, and this, together with the deposit of carbon on the surface of the burner, greatly reduces its total resistance. In practice the process is applied until the specific resistance of the carbon is reduced from one-fourth to two-thirds the specific resistance of the original carbon. III., 1376-7, **5504-7.**

Nearly all the electric light companies subject their carbons to this process. III., 1377, **5507.**

Note: The Edison Company does not make use of this process.

is applied to the burners as they leave the carbonizing furnace. III., 1381, **5523.**

The effect of hydro-carbon treatment in reducing the specific resistance of carbon is well illustrated by two lamps in evidence. One burner has been subjected to slight treatment to consolidate its structure, and has a total resistance of three hundred and thirty ohms. The other, originally made from smaller thread, has been treated until built up by the carbon deposit to the same size as the first-mentioned burner, and has a total resistance of only eighty ohms. III., 1403, **5609-12.**

was a process known to the art prior to date of filing the application of patent in suit. III., 1413, **5649.**

Burners of Shallenberger's Sawyer-Man lamps, were subjected to treatment, after carbonization in furnace and before mounting in lamp chamber, in an attenuated atmosphere (1-48th to 1-64th or less of an atmosphere) of hydro-carbon gas. This attenuated gas was used in order to get a deposit of carbon within the pores of the fibrous carbon burner rather than a deposit on its surface. Consulted Sawyer-Man Patent No. 211,262 of January, 1879, for this method of treatment. The method pursued was more like than unlike the present method pursued by Westinghouse Company in making commercial lamps (McKeesport suit). III., 1424-7, **5694-705.**

HYDRO-CARBON TREATMENT—(*Continued*):

At the present time, when the hydro-carbon treatment is employed, an attenuated atmosphere of hydro-carbon gas is employed. The principal advantage of this attenuation is that the gas enters into and deposits carbon within the pores of the burner. Does not find this process described prior to January 5, 1880, excepting as inferred from Sawyer-Man Patent No. 211,262 (McKeesport suit). III., 1429, **5713-5.**

Sawyer-Man Patent No. 211-262 contains no reference to the use or treatment of a vegetable carbon (McKeesport suit). III., 1430, **5719.**

While Sawyer-Man Patent No. 211,262 directs that a hydro-carbon liquid may be used in treating the carbon, it contains no warning against treating the same in a hydro-carbon gas (McKeesport suit). III., 1431, **5720.**

Burners of Shallenberger's Sawyer-Man lamps were treated so as to fill the pores with carbon and not to obtain an exterior coating or shell of the same. The hydro-carbon used was natural gas. None of the materials mentioned in Sawyer-Man patent as operating satisfactorily were tried, namely, naphtha, turpentine, bees'-wax, balsam and most oils (McKeesport suit). III., 1432, **5721-3.**

A thick outer shell of carbon deposited upon a burner of a high resistance lamp is detrimental. The manufacturer of lamps endeavors to secure uniformity of resistance at all points throughout the cross-section of a burner, so that the current will flow uniformly throughout the mass. A deposited outer shell would conduct an undue proportion of the current (McKeesport suit). III., 1433-4, **5726-30.**

Sawyer-Man Patent No. 211,262 clearly describes a process of building up carbon pencils by external deposit of carbon upon them. Does not think patent is confined to this process. It also describes process of building up carbons by deposition of such a thickness that burners may be cut from the deposited carbon itself (McKeesport suit). III., 1434-6, **5732-42.**

causes large reduction in resistance of carbon made from blotting paper, largely owing to its porosity. A burner made from this paper would not be useful unless subjected to this treatment. When so treated it makes a good burner for lamps of low resistance (McKeesport suit). III., 1459, **5836.**

Admits never having tried this process with liquid hydro-carbons, but only with vapors from the same. Thinks that treatment in hydro-carbon liquid would result in causing the deposit of carbon to take place mainly on the surface of the burner, thus forming a shell which would prevent a deposit in its pores (McKeesport suit). III., 1460, **5838.**

HYDRO-CARBON TREATMENT—(*Continued*):

in a vapor can be made to produce greater reduction in the specific resistance of the carbon and increase in its consolidation by internal deposit, the more porous the carbon (McKeesport suit). III., 1460, **5840.**

The burners of Shallenberger's Sawyer-Man lamps were subjected to the same treatment as the burners of commercial lamps now made by Westinghouse Company (McKeesport suit), III., 1462, **5847.**

LAMP CHAMBER:

As a purely commercial matter it has been found that the modern lamp which is thrown away when the carbon breaks is the most feasible form of lamp to use. The view taken by Sawyer and Man was that a lamp should be so constructed that the burner could be renewed. III., 1399-400, **5596-8.**

No commercial lamp which is, or, for some years, has been in use has a lamp chamber made with separable parts; and no lamp having a chamber made up of a glass globe and glass stopper ground to fit the same has been put on the market by the American Electric Light Co. of New York (McKeesport suit). III., 1438, **5751.**

LAMP, INCANDESCENT:

All lamps in commercial use have had their burners subjected to some special treatment after their carbonization in the furnace and before the sealing up of the exhausted chamber. III., 1381, **5523.**

Modern lamps cost from twenty to thirty-five cents each. III., 1399, **5596.**

The modern lamp is thrown away when it fails. As a commercial matter it has been found that this is the most feasible form of lamp to use. III., 1399-400, **5596-7.**

Defendants' Exhibits Shallenberger Lamps were run at high incandescence during exhaustion for two or three hours. This was the extent of their use. Other similar lamps were put on tests. III., 1404-5, **5616-7.**

Burners of commercial lamps made by Westinghouse Company vary in power from 10 to 75 candles, and in diameter from .0055 to .018 of an inch. They require an electro-motive force of 50 to 100 volts, and leading wires which vary in diameter from .014 to .033 of an inch. A 150 candle-power lamp containing two 75 candle-power burners is also made by this company. III., 1415, **5658.**

Lamps of 16 candle-power are much more generally used than any others. III., 1415, **5659.**

LAMP, INCANDESCENT—(*Continued*):

Defendants' Exhibit Lamp with Sawyer-Man Carré Carbon was tested only long enough to ascertain the amount of current required to bring it up to incandescence. This lamp, excepting the carbon burner, was made in the way employed in manufacture of commercial lamps at present time. III., 1421-2, **5684-5.**

No commercial lamps contain nitrogen gas either attenuated or at atmospheric pressure (McKeesport suit). III., 1437, **5747-8.**

Bernstein series lamp was introduced into use about 1883 (McKeesport suit). III., 1447, **5785.**

Shallenberger's Sawyer-Man Lamp No. 1 was run at 10 candle-power and required 14.5 volts, 7.3 amperes and 105.8 watts, or 10.58 watts per candle-power. Lamp No. 7 was run at one and one-half candles, and No. 8 at twenty candles (McKeesport suit). III., 1459, **5833-4.**

The Westinghouse 150 candle-power lamp contains two burners of the same size and with same platinum leading wires as a 75 candle-power lamp. III., 1467, **5868.**

The lamps used and sold by the Westinghouse, Sawyer-Man, and Consolidated Companies, and by defendant, are the same lamps, made in the same way and by the same manufacturing concerns. III., 1468, **5872.**

List of lamps made by Westinghouse Company given, with dimensions of the burners, etc. III., 1482-3, **5928-9.**

LEADING WIRES:

The usual sizes of the platinum leading wires used in commercial lamps varies from .012 to .016 of an inch in diameter. III., 1387, **5545.**

of commercial lamps made by Westinghouse Company vary from .014 to .033 of an inch in diameter. III., 1415, **5658.**

LENGTH:

The shorter and thicker an arch-shaped burner, the greater is the difference between the length of its outer and inner edge. This causes more current to flow along the inner edge and greater heating there than along the outer edge. This irregular distribution of heat is detrimental to life of burner. The outer edge of burner in drawing in Sawyer-Man Patent No. 317,676 is one-third longer than its inner edge (McKeesport suit). III., 1448-9, **5790-3,** and 1452, **5805.**

With same candle-power and efficiency, the longer a burner is made the smaller is the current required to operate it (McKeesport suit), III., 1455,

LENGTH—(*Continued*):

5820. Note: Under the conditions above given, the radiating surface must remain constant and the diameter must be diminished in direct proportion to the increase in length.

MULTIPLE ARC:

The Edison lamps, given in defendant's list, which range from about 74 to 32 ohms when in use (hot), can be profitably used in multiple arc for lighting a group of buildings located near each other and not more than a few hundred feet from the source of electricity. Those lamps, which have a hot resistance of about nine and one-half ohms and less, are entirely unsuited for practical multiple arc use. III., 1384, **5533-5.**

Thomson-Houston series lamps are not adapted for use in multiple arc. They are of sufficiently low resistance to make them suitable for currents of 9 or 10 amperes or more and are, therefore, of comparatively large cross-section and short length. III., 1388, **5552.**

system of distribution, which was known prior to 1880, is very largely used to-day for working a large number of lamps located in the same building; that is, in what is known as an isolated plant. Lamps having the same resistance as defendants' M and Zig-zag paper lamps (40 and 80 ohms when hot) are used to a considerable extent in such plants. III., 1416, **5663-4.**

Lamps of 40 ohms resistance when hot, if used in multiple arc and supplied from a single source, would be commercially useful to light a number of large buildings located within a few hundred feet of each other. III., 1417, **5666.**

Isolated plants with lamps in multiple arc are in very extensive use to-day. III., 1418, **5671.**

All commercial lamps of to-day which are intended for use in multiple arc have burners of great length compared with their diameter, so that they assume the filamentary character (McKeesport suit). III., 1444, **5773.**

Shallenberger's Sawyer-Man lamps require an electro-motive force of twelve to thirty volts, or about an average of twenty volts. These lamps, or lamps of similar resistance (requiring the same electro-motive force), would be practically adapted for use in multiple arc. The electro-motive force now used by the Edison Company (referring to simple multiple arc circuits) is not as low as could be practically used for any commercial purposes (McKeesport suit). III., 1451, **5804.**

In a multiple arc arrangement of circuits the lamps are connected directly to the two main conductors, and each lamp is independent of every other lamp. III., 1477, **5908.**

MULTIPLE SERIES:

In a multiple series system of circuits two or more lamps are connected in series with each other, and these series groups of lamps are connected across the two main conductors. The multiple series system is not equivalent to a multiple arc system or equally available for central station lighting as, in the former system, the interruption of any lamp of a group extinguishes the other lamps of that group. To overcome this difficulty, additional appliances are required which render such system complicated and impracticable. Multiple series systems of distribution have never been very largely introduced. III., 1478, **5909.**

system of distribution requires the substitution of an equivalent resistance in place of a lamp when the latter is to be extinguished, resulting in this disadvantage, that the same amount of energy is required whether the lamps are in use or not. This system is only useful when circumstances require a practically constant number of lamps to be in use, as in street lighting. Such systems have been used in a limited way, but no companies are regularly installing them. The multiple series arrangement of resistances and other electrical appliances was well understood in 1878, and it would likewise have been understood that electric lamps could be arranged in multiple series without changes in the lamps themselves. III., 1481-2, **5921-7.**

RESISTANCE:

of a carbon burner when cold is about double what it is when hot. III., 1376, **5502.**

Lamps of forty ohms resistance when hot, if used in multiple arc and supplied from a single source, would be commercially useful to light a number of large buildings located within a few hundred feet of each other. III., 1417, **5666.**

of carbon burners shown in Figs. 3 and 4 of Sawyer-Man Patent No. 317,676, if subjected to same processes during manufacture as were the burners of Shallenberger's Sawyer-Man lamps Nos. 4 and 5, would hardly be of one ohm resistance. Relatively, the resistance of these Shallenberger burners would be from twenty to thirty times that of the burner shown in patent (McKeesport suit). III., 1454-5, **5814-7.**

of Schallenberger's Sawyer-Man lamp No. 1 is nine ohms when cold and four and one-half ohms when hot. That of the other Shallenberger lamps is much higher (McKeesport suit). III., 1455, **5817-9.**

RESISTANCE, SPECIFIC:

The application of the hydro-carbon treatment results in a consolidation of the carbon by filling its pores. This results in a marked reduction of its specific resistance, and this, together with the deposit of carbon on the surface of the burner, greatly reduces its total resistance. In practice the

RESISTANCE SPECIFIC—(*Continued*):

process is applied until the specific resistance is reduced from one-fourth to two-thirds the specific resistance of the original carbon. III., 1376-7, **5504-7.**

The effect of hydro-carbon treatment in reducing the specific resistance of carbon is well illustrated by two lamps offered in evidence. One burner has been subjected to slight treatment to consolidate its structure, and has a total resistance of three hundred and thirty ohms. The other, originally made from smaller thread, has been treated until built up by the carbon deposit to the same size as the first mentioned burner, and has a total resistance of only eighty ohms. III., 1403, **5609-12.**

In making Shallenberger's Sawyer-Man lamps the hydro-carbon treatment deposited carbon in the pores of burner and lowered its specific resistance (McKeesport suit). III., 1427, **5707.**

Has succeeded in reducing the specific resistance of and in hardening and toughening carbonized blotting paper by electrically heating it in a nitrogen atmosphere (McKeesport suit). III., 1428, **5710.**

of a carbon burner should be uniform at all points throughout its cross-section, so that the current shall flow uniformly throughout the mass. A thick outer shell of deposited carbon is detrimental in a high resistance lamp, because, being of lower resistance than the rest of the burner, it will conduct an undue proportion of the current (McKeesport suit). III., 1433-4, **5726-30.**

A fine filamentary burner has the advantage over a short, thick burner in that the resistance through various parts of its cross-section is not so liable to vary. Points of lowest resistance will conduct the most current and become hottest, a result which is detrimental to the life of the burner (McKeesport suit). III., 1447-8, **5786-9.**

The more porous the carbon the greater the reduction in its specific resistance and increase in its consolidation obtainable from an internal deposit of carbon by subjecting it to hydro-carbon treatment in a vapor (McKeesport suit). III., 1460, **5840.**

SEALING:

Some of Defendant's Exhibits Shallenberger Lamps show cracks in the glass around the platinum wires near the inner end of the joint. This often occurs in lamps of one hundred and fifty candle-power, in which the leading wires are larger than in commercial lamps having the candle-power of a common gas jet. III., 1410-11, **5640-1.**

SERIES:

Edison lamps contained in defendant's list, which are designated as "Municipal," are especially adapted for use in series. The other "small

SHALLENBERGER, Oliver B.

SERIES—(*Continued*):

lamps" could be so used to advantage in special cases, but not in multiple arc for any extended distribution. III., 1385, **5538.**

lamp of Bernstein was introduced into use about 1883 (McKeesport suit). III., 1447, **5785.**

UTILITY:

Lamps of forty ohms resistance when hot, if used in multiple arc and supplied from a single source, would be commercially useful to light a number of large buildings located within a few hundred feet of each other. III., 1417, **5666.**

VACUUM:

No commercial lamps contain nitrogen gas, either attenuated or at atmospheric pressure (McKeesport suit). III., 1437, **5747-8.**

Commercial lamps of to-day have an atmosphere of air exhausted to highest possible degree of tenuity (McKeesport suit). III., 1438, **5750.**

Shallenberger's Sawyer-Man lamps contain either a vacuum or attenuated atmosphere of nitrogen gas. III., 1465, **5859.**

SHARP, William.

was employed as an expert mechanic by Sawyer & Man, at Howard Street, at Walker Street, and afterwards by Mr. Sawyer, at Ansonia (McKeesport suit). V., 3342-5.

BURNER OF CARBON:

In the lamp made for Mr. Man, before my connection with Sawyer & Man, there was a pencil of retort carbon (McKeesport suit). V., 3343.

Before going to work for Sawyer & Man at the Howard Street shop, I worked on a disk of carbon at Brooklyn for Mr. Man. I got a small piece of carbon and filed it down flat, then turned it to about the thirty-second of an inch thick. It was turned down to about half an inch in diameter, with a hole in it about a quarter of an inch in diameter (McKeesport suit). V., 3343.

At Walker Street, I worked making parts of lamps. I used to file down to proper length and size long strips of carbon ranging from about a sixteenth to somewhere about three-sixteenths of an inch in diameter, which were imported from France. They were hard carbons, similar to those burned in arc lamps. They were straight and round, and not quite as hard as glass, but would break quite as easily (Witness makes a sketch of the burner made from this carbon) (McKeesport suit). V., 3347-8.

At Walker Street, I saw no other kinds of carbon than the retort and imported French carbon. I only remember seeing pencil burners made from the French carbon. I made two or three circular carbons from retort carbon. They were from one-half to three-quarters of an inch in diameter and about a thirty-second of an inch thick. One of these circular carbons was cut in two, and the half circular piece was put into a lamp. I never saw but one such burner made and put into a lamp (Witness makes a sketch of the circular carbons) (McKeesport suit). V., 3394-50.

At Walker Street, willow charcoal in the form of crayons, about five-sixteenths of an inch in diameter was filed down to about the same size as the French carbon pencils, of which I have made a sketch (p. 3348), and a deposit of carbon was formed over it, after which the charcoal core was removed (McKeesport suit). V., 3353-4.

At Walker Street I never saw any willow charcoal or crayons, or any form of charcoal or wood carbon used in any way, except for the purpose of obtaining a deposit of carbon on the willow charcoal pencil, the latter be

BURNER OF CARBON—(*Continued*):

ing afterwards removed, leaving nothing but the hollow pencil of deposited carbon. Never saw any wood carbons or wood charcoal of any kind, except the willow crayons. Never saw at either of the shops any one carbonize any material of any sort, except the willow charcoal. I never saw, nor heard about, nor worked on any carbon made from paper, nor saw any one working on or using any carbon made from paper of any kind. I never heard any one saying that such carbon had been used in any way, or that any one had tried to use it in any way at either of the workshops. At Ansonia, somewhere about 1880, after Mr. Sawyer had left there, I saw Mr. Wallace and Mr. Howell trying to make carbon out of paper, Mr. Wallace saying he had read in the paper of Edison's work on paper carbon. (McKeesport suit). V., 3354-5.

Never saw any one in either of the Sawyer-Man shops making or altering any curved, or semi-circular, or circular carbons of any kind, except the (three) circles of hard carbon made by myself (McKeesport suit). V., 3356.

I never heard nor saw anything of paper carbons until a year or two after May, 1879 (McKeesport suit). V., 3368.

I assisted Mr. W. E. Sawyer, and worked on a lamp in New York containing a circular carbon like that shown in drawing of Patent No. 317,676. Don't think more than two such lamps were made. Think the circular carbon was too bothersome (Exhibit Sharp's Statement). V., 3417.

Some time after Sawyer left Ansonia I knew of Mr. Wallace trying to carbonize a piece of paper, but, as far as I know, it was never put into a lamp. I believe he was led to it by the publication of Edison's experiments (Exhibit Sharp's Statement). V., 3418.

CARBONIZATION:

I never at Walker Street saw crucibles put into the boiler furnace more than three or four times, and never knew of any of the contents of any of these crucibles being used in any of the lamps, and never did any work, nor saw any one do any work, on any material that I knew, or was told, came out of these crucibles (McKeesport suit). V., 3358.

CLAMPING:

The carbons, made at Walker Street from hard French carbon, rested on a larger carbon point made from gas retort carbon. The one made from a half circle of retort carbon was held in retort carbon clamps by means of platinum screws and nuts (McKeesport suit). V., 3348-50.

The clamps for the half circular retort carbon disk burners were made of retort carbon held in place by platinum screws and nuts (McKeesport suit). V., 3351.

CROSS-SECTION:

The carbons that I filed from hard carbon at Walker Street were round and straight, and of the size represented in this sketch (Witness makes a drawing of the carbon) (McKeesport suit). V., 3347-8.

After the willow twig charcoal burners had received the deposit of carbon, they were about an eighth of an inch thick (McKeesport suit). V., 3354.

The ring of gas retort carbon made at Walker Street was from half to three-quarters of an inch in diameter and about a thirty-second of an inch thick. (Witness makes a sketch to show the size). The ring was cut in two, and one-half of it used as a burner (McKeesport suit). V., 3349-50.

I never knew nor heard of Sawyer & Man experimenting with an incandescent conductor as long as two or three inches and the size of a horsehair (Exhibit Sharp's Statement). V., 3416.

DURABILITY:

I never, at the Sawyer-Man shop, saw a lamp burn more than half an hour at any one time. They were then taken apart, cleaned, and set up again with new carbons (McKeesport suit). V., 3357.

I never saw any of the feeder lamps made at Ansonia that lasted more than half an hour (McKeesport suit). V., 3360.

EVAPORATION:

The Sawyer-Man lamps at Walker Street became smoky, by the carbons, or pencils, burning out (McKeesport suit). V., 3406.

GASES:

At Walker street, Mr. Myers used to expel all the air that could be got out from the lamp globes, before charging them with gas (McKeesport suit). V., 3352.

Towards the last of my working in Walker Street the glass was all made hot to expel all the air (McKeesport suit). V., 3406.

HYDRO-CARBON TREATMENT:

The willow-twig charcoal burners were put into a closed vessel in which was gas, and a current of electricity was sent through them. By this means carbon was deposited on the burners (McKeesport suit). V., 3354.

For treating the carbons, they used to have two metal rods at the bottom of an old lamp, and place a carbon on the upper end of one rod, with the electric wires on the other, and immerse the carbon end in the oil. Sawyer used a current of electricity (McKeesport suit). V., 3365.

LAMP-CHAMBER:

In the Sawyer-Man lamps the working parts were all mounted on a base plate. When the lamp was put together the working parts were inserted into the glass globe, and the base plate clamped by two rings and screws to the flange of the glass globe (McKeesport suit). V., 3389.

Between the metal base and the glass globe we used to put paper washers as packing (McKeesport suit). V., 3409.

I never heard of the interior of the Sawyer & Man lamp being enclosed in a globe entirely of glass (Exhibit Sharp's Statement). V., 3417.

SAWYER'S FEEDER LAMP:

At Ansonia the work done was manufacturing feeder lamps. These were lamps with a long, thin, hard carbon pencil, arranged by reversing the current, so as to feed the lamp into contact, in case it burnt out or broke away in any way. I never saw one burn more than half an hour. The lamps were made with a disk of metal with two upright posts. One had a kind of bend, an L; the carbons were clamped between the two posts, and the whole supported by a zigzag strip of metal. The whole was enclosed in a glass case (McKeesport suit). V., 3360-1.

I saw at Sawyer-Man's a lamp resembling Fig. 52, in Sawyer's book on "Electric Lighting." The carbon was retort carbon. At Wallace & Sons, Ansonia, I made the parts of one hundred feeder lamps (McKeesport suit). V., 3362-3.

I believe Mr. Sawyer considered the feeder lamps made at Ansonia better lamps than any which were made at New York (Exhibit Sharp's Statement). V., 3417.

SAWYER-MAN LAMP:

Prior to being employed by Sawyer & Man, I made two lamps at my residence in Brooklyn for Mr. Man. One had an enclosed glass with two holes at the bottom to put the working parts of the lamp through. It was put together at the holes with a kind of clamp or washer, and there were two nuts at the bottom. There was in the lamp a pencil of retort carbon (McKeesport suit). V., 3342-3.

I do not know any time when Sawyer & Man had at Walker Street more than a dozen lamps. I never knew of their selling any (McKeesport suit). V., 3356.

I considered the Sawyer-Man lamps nothing but an experiment (McKeesport suit). V., 3366.

At all the places of Sawyer & Man at which I worked, I do not think I ever saw more than fifty lamps all together (McKeesport suit). V., 3405.

SAWYER-MAN LAMP—(*Continued*):

The general type of lamp upon which Sawyer & Man were experimenting during my employment by them was as follows: The lamp contained a glass globe about eight inches long by about two inches in diameter. The base of the globe, by nuts and washers, was fastened to glass plates; the glass plate and the globe were clamped together by metal rings. The interior part of the lamp was fastened to the base of the lamp in different ways. The base of the lamp was then surrounded with melted sealing wax; after this was done the base was placed in a metallic shell and filled with bees-wax. The interior of the lamp contained a short pencil of carbon; a disk of soapstone or metal separated the illuminating part of the interior from the radiators such as are shown in figure 1, of Letters Patent 205,144. The shape and character of these radiators, however, differed, some being serpentine and some of other shapes (Exhibit Sharp's Statement). V., 3413.

SAWYER-MAN WORKSHOP:

At Howard Street we worked in the shop of Arnoux & Hochhausen and used their tools. The small tools used were our own (McKeesport suit). V., 3344-5.

At Walker Street Sawyer and Man had a small dynamo, a lathe, a grindstone, a boiler, an engine and two vises; except the lathe and vises, we mostly furnished our own tools (McKeesport suit). V., 3346.

At Walker Street four men were employed, and at Howard Street two men (McKeesport suit). V., 3359-60.

I never saw nor knew of Sawyer and Man having an air pump, or any apparatus for obtaining a high vacuum. They sent their lamps out (Exhibit Sharp's Statement). V., 3416.

SEALING:

After the Sawyer-Man lamps were charged with gas they were sealed with sealing wax (McKeesport suit). V., 3407.

SHAPING:

The carbons that I worked on at Walker Street were long, round, straight strips of carbon, similar to that used in arc lamps. They were imported from France, and were filed into proper length and size from long wire-like strips, ranging from about a sixteenth to about three-sixteenths of an inch in diameter. The carbon was not quite as hard as glass, but would break quite as easily (McKeesport suit). V., 3347.

VACUUM:

If Sawyer and Man had had any apparatus for obtaining a high vacuum, I should have been apt to know it, but I never knew anything of their having such apparatus (Exhibit Sharp's Statement). V., 3416.

SIEMENS, C. WILLIAM:

states, in 1879, that he is a member of the firm of Siemens Brothers, and that they have made a large amount of apparatus and wire for land and cable telegraphs. VI., 4111.

SUBDIVISION:

If the light was subdivided into various lights, he states that "The comsumption of energy increases in a very rapid ratio, inversely as the concentration of the light. In dividing the light into two lights each will probably not give them more than one-fourth of the effect."

As to Mr. Edison's attempt to subdivide the light and make it applicable to rooms and dwellings with great ease and cheapness, thinks that he can no doubt produce a steady and possibly an agreeable light, but that he has yet to prove that he can produce a cheap light. "Our experience, as far as I can judge from my own, leads me to an opposite conclusion" (Testimony before the Parliamentary Committee on Lighting by Electricity, April 29, 1879). VI., 4112.

SIEMENS, DR. WERNER:

SUBDIVISION:

After referring to some applications which have been made of the arc light, the writer says: "Up to within a few years, however, a great obstacle stood in the way of the more general extension of the electric light—its slight divisibility. It was not possible until then to place more than one arc light in a conductor with safety." After giving reasons for this, he says: "In order to remedy this fault and to make an unlimited subdivision of the electric light possible, very many attempts have been made, and up to the most recent time, to make use of thin carbon or metal rods (instead of the arc light), which are made incandescent by the electric current as sources of light. A light so produced, however, is comparatively feeble, takes much current, therefore much power, and, indeed, is as yet hardly to be called an electric light" ("Zeitschrift für Angewandte Elektricitätslehre," for 1879). VL, 4139.

SMITH, H. Julius:

states that from 1863 until about 1874 he was an expert mechanic for Moses G. Farmer, who was experimenting on the electric light, and that he first became acquainted with Dr. Isaac Adams in 1864 or 1865.

ADAMS'S LAMP:

In 1864 or 1865, Dr. Adams discussed the subject of electric lighting with me. He knew of the work I was engaged on for Prof. Farmer, and told me it would lead to no commercial result, as platinum burners were not suitable (Affidavit of September 30, 1890). IV., 2729, **10915.**

Dr. Adams brought one of his (carbon) lamps to my shop, and I ran it on my dynamo for him. It give a brilliant white light, and worked well for half an hour or an hour—as long as we ran the dynamo. The lamp was in good condition when we stopped. Am sure I saw the lamp at Dr. Adams's laboratory some time prior to 1868 (Affidavit of September 30, 1890). IV., 2730, **10920.**

I do not recollect speaking to Prof. Farmer or to any one else about the work of Dr. Adams on this carbon lamp of his. IV., 2732, **10926-7.**

CROSS-SECTION:

Should judge that the burner in the Adams lamp which I saw, and which is referred to in my affidavit, was an inch, or an inch and a quarter in length, varying from a sixteenth to half an inch in width, and from a half of one-thousandth to three one-thousandths of an inch in thickness, the same being the size of platinum foil burner which Prof. Farmer used in his lamp. IV., 2732, **10929.**

DYNAMOS:

The dynamo on which I ran Dr. Adams's carbon lamp for him was a very poor one. It was intended for electro-plating. IV., 2732, **10928.**

SEALING:

During my early acquaintance with Dr. Adams he discussed the subject of electric lighting with me. He said that the carbon could be preserved from destruction when incandescent by enclosing it in a vacuum globe made and exhausted in precisely the same way as his Geissler tubes were made and exhausted. He spoke of the difficulty of preventing leakage from the expansion and contraction of the wires where they passed through the globes, and said that he had difficulty in obtaining a glass that would remain permanently sealed to the wires, but that he had got over that difficulty by using a kind of glass that had substantially the same co-efficient of expansion as the platinum wires. I think he said he had to make the glass himself in order to get the desired result (Affidavit of September 30, 1890). IV., 2729-30, **10914-20.**

STILLMAN, THOMAS B.:

is an analytical chemist and Professor of Chemistry in Stevens Institute, Hoboken, N. J. Made apparatus for and did the charging of the Sawyer-Man lamps during their experiments in 1878-9.

BURNER OF CARBON:

The carbons used in the Sawyer-Man lamps at Walker Street, were of various form and material, viz.: straight willow carbon, treated and untreated; the straight Carré carbon; the horseshoe carbon, treated and untreated; hollow willow carbon, treated; the plain arch and the straight willow (McKeesport suit). II., 1105, **4417-18.**

Of the forty or fifty Sawyer-Man lamps filled with nitrogen at Walker Street, about a third had arch-shaped paper carbons; of the hundred to a hundred and fifty filled at my laboratory, probably a quarter had the arch-shaped paper carbon (McKeesport suit). II., 1106-7, **4423-6.**

In the lamps called hammer and anvil lamps, straight pencils of hard carbon and willow carbon, treated and untreated, were used (McKeesport suit). II., 1131, **4524.**

CLAMPING:

In the Sawyer-Man lamp, large pieces of carbon, connected with the ends of the brass rods or tubes, acted as receivers for the carbon pencils used as illuminants. Various devices were used to maintain perfect contact between these larger pieces of carbon and the carbon used as an illuminant. In the straight pencil lamp a long and delicate spring, extending from the upper portion of the brass conductor, was connected with the upper end of the pencil and extended to the base of the lamp, retaining the pressure of the carbon uniform when in a heated condition (McKeesport suit). II., 1105, **4419.**

CROSS-SECTION:

The straight pencil carbons in the Sawyer-Man lamps, which I filled with gas, varied in thickness, some being quite small, and others relatively large. The carbons shown by Mr. Knowles (something over a thirty-secondth of an inch) were about the smallest size for use in lamps with straight pencils, though some of the carbons would have a diameter three times as large. The carbons used were generally Carré carbons. II., 1100-1, **4400-3.**

DURABILITY:

I produce a record of some lamps sent to me to be filled with nitrogen gas in January, 1879 (McKeesport suit). II., 1108, **4429-33.** (Note. The record shows lamps that burned from four to fifteen minutes, the latter duration being called good.)

DURABILITY—(*Continued*):

Several of the Sawyer-Man lamps burned finely for a number of days, while one in particular burned several weeks in the shop at Walker Street, and was in good condition when broken accidentally by one of the workmen in hammering something on the wall. This lamp was of the construction called hammer and anvil, and had a straight treated carbon, and was filled with nitrogen gas (McKeesport suit). II., 1112, **4447-9.** (Note. Witness testifies later [II., 1123] that, except as he visited 94 Walker Street, he had no personal knowledge of what was done to the lamps after they left his hands.)

HEATING DURING EXHAUSTION:

When the air in Sawyer-Man lamp had been displaced, a current of electricity was turned into the lamp and the carbon maintained in a state of incandescence from half an hour to an hour, to drive out any occluded gases that might be present (McKeesport suit). II., 1106, **4421.**

HYDRO-CARBON TREATMENT:

Mr. Sawyer had a process of depositing carbon in a very fine state of division upon pencils of coarse material, by decomposition of hydro-carbon, this coating being very hard and uniform (McKeesport suit). II., 1130, **4520.**

LAMP CHAMBER:

In the Sawyer-Man lamps sent to my laboratory, the globe was fastened to the base, first by having the surfaces of the glass evenly ground, with Canada balsam placed between to fasten them together, and then by long screws running from the upper flange of the base of the globe through to the lower glass plate and there secured. There were metal rings or flanges, used above and below the base of the lamp. In a few instances I sealed the lamps by pouring a mixture of sealing-wax and caoutchouc round the base of the lamp (McKeesport suit). II., 1120-2, **4480-4.**

NITROGEN GAS:

I arranged an apparatus for Sawyer & Man for ensuring the purity of the nitrogen gas used in filling their lamps (McKeesport suit). II., 1103, **4409.**

In filling the Sawyer-Man lamps with nitrogen gas, the gas was passed through a tube to the upper end of the globe, and the air displaced by the nitrogen passing out through an aperture at the base in the other side. When the air had been displaced, a current of electricity was turned into the lamp, and the carbon maintained in a state of incandescence from one-half an hour to an hour, to drive out any occluded gases that might be present (McKecport suit). II., 1105-6, **4420-1.**

At Walker Street I filled forty or fifty Sawyer-Man lamps with nitrogen gas, and at my laboratory one hundred to one hundred and fifty lamps (McKeesport suit). II., 1106-7, **4423-5.**

NITROGEN GAS—(*Continued*):

Mr. Sawyer and Mr. Man were under the impression that their earlier apparatus for supplying nitrogen to the lamp globes allowed a trace of moisture to remain in the nitrogen, and I devised an arrangement for depriving the nitrogen of all traces of moisture. If moisture were left in the gas it would, on coming in contact with the incandescent conductor, be converted into oxygen and hydrogen. The oxygen would then unite with the carbon to form carbonic acid, and the pencil would be speedily destroyed (McKeesport suit). II., 1128, **4509-10.**

SAWYER'S FEEDER LAMP:

I was acquainted with the feeder lamp of Mr. Sawyer, and it is my impression that I filled a few of them for him. These lamps were much larger than the Sawyer-Man lamp. They were made at his factory on Fulton street. I never saw a feeder lamp at 94 Walker Street nor ever heard of their being used there (McKeesport suit). II., 1116-7, **4463-4467.**

SAWYER-MAN LAMP:

The Sawyer-Man lamps made at 94 Walker Street were all incandescent lamps, the light being given by a piece of incandescent carbon. The carbons were of various forms and materials. There were the straight willow carbon, treated and untreated; the straight Carré carbon, the horseshoe paper carbon, treated and untreated; also the willow carbon, hollow and untreated, the plain arch and the straight willow. The lamp consisted essentially of two metallic electrodes of various forms, but usually of two pieces of brass conductors passing through the base of the lamp, one to about three-quarters of the distance up, the other parallel to it and extending some distance further up the globe. The ends of the brass rods or tubes were connected to large pieces of carbon, which acted as the receiver for the pencils of carbon used as an illuminant. Various devices were made use of to maintain the contact of these larger pieces of carbon perfect with the carbon used as the illuminant. In the straight pencil lamp, a long and delicate spring, extending from the upper portion of the brass conductor connected with the upper end of the pencil, extended to the base of the lamp, retaining the pressure of the carbon uniform when in a heated condition. In the arch lamp, however, no use was made of the spring for that purpose, as it was found by experiment that the passage of the current through the carbon arch did not rupture the carbon, and that the arch itself relieved the carbon of the strain. In filling the lamps with nitrogen gas, the gas was passed through a tube to the upper end of the globe, the air displaced by the nitrogen passing out through an aperture at the base in the other side. When the air had been displaced, a current of electricity was turned into the lamp and the carbon maintained in a state of incandescence from one-half hour to an hour, to drive out any occluded gases that might be present. The filling tube was then withdrawn, valves turned and the lamps closed. The base of the lamp consisted of two glass plates attached to the ends of the globe by means of screws running up through the plates. The plates

4

STILLMAN, Thomas B.

SAWYER-MAN LAMP—(*Continued*):

were joined together by means of Canada balsam when the lamps were filled; sealing wax was then placed around the base, securing the interior of the globe from admixture with the air outside. To overcome the difficulty of the softening of the wax, a mixture containing caoutchouc was used, which when cold adhered firmly to the glass and made a tight joint. The globe of the lamp was long and cylindrical, about two inches in diameter and six to ten inches in length (McKeesport suit). II., 1105-6, **4417-23.**

SAWYER-MAN WORKSHOP:

At Sawyer & Man's workshop, 94 Walker Street, there was an apparatus for preparing nitrogen to be used in filling their lamps (McKeesport suit). II., 1104, **4416.**

The apparatus used at 94 Walker Street, for exhausting the lamp globes before filling them with nitrogen, was a simple water exhaust (McKeesport Suit), II., 1111, **4441.**

SEALING:

The base of the Sawyer-Man lamps made at Walker Street, consisted of two glass plates attached to the end of the globe by means of screws running up through the plates. The plates were joined together by means of Canada balsam, when the lamps were filled. Sealing-wax was then placed around the base, securing the interior of the globe from admixture with the air outside. To overcome the difficulty occasioned by the melting of the wax a mixture containing caoutchouc was used, which when cold adhered firmly to the glass and made a tight joint (McKeesport suit). II., 1106, **4421-3.**

Generally speaking, when the carbon in a Sawyer-Man lamp proved defective, the lamp was taken apart and a new carbon inserted. In some instances, however, some of the lamps were not set up again. If a lamp which had been thoroughly cleaned and the wax or sealing material used at the base of the lamps entirely removed, there would be no means of knowing whether the lamps were old lamps with new carbons, or fresh lamps which had not before been filled. But in nearly every instance the lamps sent to me showed traces of sealing wax or of other material they used for sealing the outside of the lamps (McKeesport suit). II., 1124-6, **4494-50.**

VACUUM:

A slight exhaust was left in the chamber of the Sawyer-Man lamps after they were filled with gas, so that, when the lamps were burning, the gas, being expanded by the heat generated by the incandescent carbon, would be under normal atmospheric pressure (McKeesport suit). II., 1115, **4459-60.**

STOWELL, Charles:

is an electrician. Was employed by Wallace & Sons, of Ansonia, Conn., from 1875 to 1885. Previous to employment at Wallace's, worked for Moses G. Farmer. Had charge of the electrical room at Wallace's during the time Mr. Sawyer was working there.

DURABILITY:

As to the Sawyer feeder lamp tested at Ansonia, my note-book says: "Sept. 19th, 1879. Sawyer lamp started September 11th and has burned in all 36 hours 30 minutes. Has burned off eight times and consumed in all $2\frac{3}{8}$ inches of carbon. Condition of lamp: Upper rollers cracked and burned flat on one side. Lower jaws burned out so that they did not grip the carbon. Globe badly smoked. Reason for stopping bad contact of the jaws so that the carbon would not heat." II., 1221, **4880-4881.**

CLAMPING:

Some of the lamps brought by Mr. Sawyer to Ansonia had no feeding device; they were not permanently clamped, and could have had the carbon feed, if they had had the feeding mechanism. The jaws which held the ends of the carbon were pressed upon the carbon by means of a spring. II., 1217-8, **4866-4869.**

CROSS-SECTION:

I many times saw Mr. Sawyer employ, in the lamps used by him while at Ansonia, carbon illuminants of a cross-section of $\frac{31}{1000}$ of an inch. II., 1217, **4865-6.**

HYDRO-CARBON TREATMENT:

I saw Mr. Sawyer, at Ansonia, subject carbons to electrical treatment. It made the surface silvery and smooth, like deposited metal. II., 1216, **4863.**

SAWYER'S FEEDER LAMP:

The Sawyer lamp was run in series at Ansonia. II., 1222, **4885.**

There were one hundred Sawyer feeder lamps made in one lot at Ansonia. II., 1223, **4891.**

I remember sixteen or seventeen Sawyer lamps being tried at one time at Ansonia, later than September 19th, 1879. I do not remember whether life tests of these lamps were made. II., 1223, **4892.**

SWAN, J. W.:

The designer of the Swan lamp.

BURNER OF CARBON:

Speaking of the earlier efforts of inventors to make an incandescent lamp, the lecturer says: "But carbon has been found so difficult to deal with, on account of its ready combustibility (and some other troublesome properties which I will mention afterward), that experimenters have bestowed much attention upon platinum and iridio-platinum as the incandescent material for electric lamps" (Lecture of Oct. 20, 1880). V., 3835.

EVAPORATION:

"In all the various attempts to utilize the principle of incandescence of carbon in vacuo, two great difficulties had stood in the way and baffled every attempt to overcome them. One was *the rapid wearing away and consequent breaking of the incandescent carbon*, and the other *the obscuration of the lamp by a kind of black smoke.* So uniformly did these phenomena present themselves, that the idea was propounded and generally accepted that the blackening of the lamp globes was due to volatilization of the carbon under the action of the enormous heat to which it was subjected." The lecturer then quotes from Fontaine in regard to evaporation (see digest of Fontaine under Evaporation), and says: If this idea of volatilization of carbon were founded in fact, any further attempt to render incandescent carbon lamps *durable* by means of a vacuum would be *mere waste of time*, and durable they *must* be to be of any practical value (Lecture of Oct. 20, 1880). V., 3838-9.

LAMP CHAMBER:

Speaking of his experiments, the lecturer says: "I knew that the conditions under which, without exception, all previous experiments had been tried were such as did not allow to be formed anything approaching a perfect vacuum within the lamp. Screw fittings had invariably been employed to close the mouth of the lamp and the ordinary air-pump to exhaust the air. Under such circumstances it was certain that a considerable residuum of air would be contained within it and also it would leak" (Lecture of Oct. 20, 1880). V., 3839.

SWAN, J. W.:

The designer of the Swan lamp.

BURNER OF CARBON:

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THATCHER, JAS. E.

ADAMS'S LAMP:

Says that he saw a great many sketches similar to Defendant's Exhibit Dr. Adams's Sketch No. 4, drawn by Dr. Adams during their journey abroad together in 1867. He told me that the sketches represented a miner's lamp, but I remember none of the details of construction or operation of lamp, or whether it was to be an arc or incandescent lamp. I never saw one of the lamps—only the sketches. IV., 2742-3, **10965-70.**

THOMPSON, Prof. Sylvanus P.

GEISSLER TUBES :

"Induction across a non-conducting medium is always accompanied by a mechanical stress upon the medium. If this stress is very great the non-conducting medium will suddenly give way and a spark will burst across it. Such a discharge is called a 'disruption' discharge." * * * "The dielectric strength of glass, though much greater than that of air, is not infinitely great." * * * "Thin layers of air oppose a proportionally greater resistance to the power of the spark than thick layers and possess greater dielectric strength." * * * "In rarefied air the spark is longer." * * * "The length of the spark differs in different gases, being nearly twice as long in hydrogen as in air at the same density and longer in air than in carbonic acid gas" ("Electricity and Magnetism," 1889). VI., 4391-2.

SUBDIVISION :

"Much vagueness appears to exist in the minds of men upon the possibility of dividing the electric light indefinitely, and much has recently been said and written upon the question which, if tested by sober reasoning, and by the application of elementary dynamical principles, will be found to be sheer nonsense. * * * Now the intensity of the electric light between the carbon points follows precisely the same law. It is proportionate, not to the strength of the current, but to the square of the strength of the current. * * * Now apply these matters to the problem of subdivision of the electric light. Suppose we have a current of a certain strength, which we will reckon as unity. Let us divide that current into two equal parts by dividing the resisting part of the circuit into two branches whose resistances are equal. A current of half the strength passes through each branch, producing at the point of resistance an effect of heating and illumination. We shall not get in each branch half the light of the previous case ; we shall only get a quarter, because the effect follows the square of the current strength. If we had divided the circuit into three branches, in each branch we shall get but one-ninth part of the original light. This diminution becomes serious when we consider a case of large subdivision." The author illustrates this by saying that when a current, which will give 1,000 candles with a single light, is divided among ten smaller lights, a total of ten candles of light will be obtained. From this he concludes that "clearly it might not pay to subdivide the light at this rate, though it might for particular cases pay to use the undivided current to mass the light in one bright spark of 1,000 candles brilliancy." Prof. Thomson further states that the most hopeful field for the discovery of a practical method of distributing

THOMPSON, Prof. Sylvanus P.

SUBDIVISION—(*Continued*):

the light refers to the generator of the current rather than to any method of dividing a current into many branches, and he suggests that it might be accomplished by having a dynamo generate many independent, feeble currents instead of a single powerful current (Letter to "Engineering" on "Divisibilty of the Electric Light from a Dynamical Point of View," dated October 23, 1878). VI., 4040-5.

"And now we must turn to the third of the disadvantages attending the electric light, its extreme and dazzing brilliancy, and consider some of the suggestions that have been made for reducing it to more manageable and endurable proportions. The problem of dividing the electric light is an old one. So far back as 1847 a patent was taken out in England for producing a light by passing the electric current through a thin rod of carbon, which it heated to redness, like those wires with which we experimented. The system so long ago initiated has recently been revived in England by Mr. Werdermann, of whose lamp you may have recently read in the papers. The light is not brilliant, but perfectly steady, and admits of subdivision to a certain extent. Mr. Werdermann's own statistics show, however, that subdivision is only accomplished at great sacrifice. • • • Referring to the accounts of Edison's platinum lamp the lecturer says: "He, therefore, obtains the light not by an electric arc, but by incandescence. We do not yet know the details, but to give you an idea as best I can of what I mean I have in a frame here seven little spirals of platinum wire at same distance from each other. They become white hot when the current passes through them, and were my current to become too strong one or more of them would be melted up. I am here sending the whole current at my disposal through these seven spirals, and I put it to you whether we get as much light from these seven spirals as from our arc between carbon poles. I cannot tell you what Mr. Edison's particular method of distributing the current to the spirals may be, but this I can tell you, as the result of all experience, that any system of lighting depending on incandescence will utterly fail, from an economic point of view. and will be the more uneconomical the more the light is subdivided." After comparing the relative advantages of the electric light and gas—the arc light being the only one considered—Prof. Thompson says: "The former gives us splendid concentration of light at a distinctly cheaper rate than could be obtaind by the consumption of coal gas. But the loss in subdivision is so great that for domestic purposes the use of electricity is accompanied by such an extravagant expense as not to permit of its becoming general. I do not say that the electric light will never supplant gas for domestic purposes; he would be bold who would venture to assert that anything is impossible in science; but I do say that, so far as the present state of science warrants us in pronouncing a judgment, electric lighting for domestic purposes will not pay" (Lecture on "The Electric Light," of November 9, 1878). VI., 4061-2 and 4065.

THOMSON, Prof. Elihu.

states that he is connected with the Thomson-Houston Electric Company, "Thomson" referring to himself, and that said company is engaged in the business of incandescent electric lighting, which it first took up in 1885. Understands that the Thomson-Houston Company has a license from the Consolidated Electric Light Company to make incandescent lamps, and that the latter company is controlled by the Westinghouse Company. III., 1495, **5978**; 1593, **6370**, and 1703, **6810**.

BURNER:

Irrespective of the material out of which the burners were made, straight or bent burners and the spiral form described in patent in suit, which is to be closely coiled to restrict the radiating surface, were old. III., 1609, **6433-4.**

of platinum or platinum iridium are practically useless. Edison's platinum lamp was never put to practical use. III., 1663, **6651-2.**

Pulvermacher's English patent of 1878 refers to platinum as the material for the burner in incandescent lighting. III., 1667, **6668.**

BURNER OF CARBON:

In some of the processes for producing arc light carbons, which are described by Fontaine, the carbonized material is subsequently soaked for a second or third time in carbonaceous material and carbonized after each soaking. In Carré's well-known process, the carbons are subjected to this process. These carbons were used for both arc and incandescent lighting prior to patent in suit. III., 1515-6, **6059-61.**

The process of making the tar putty burner described in patent in suit, by shaping the plastic mixture before carbonization, is not new broadly unless the omission of the subsequent process of impregnation and recarbonization, which was resorted to in some of the old processes for increasing the rigidity and density of a carbon rod or pencil, may be considered to be novel. III., 1517, **6066-7.**

If, at date of patent in suit, a skilled person had been shown a lamp like the Edison "Municipal" lamp, and had been asked to make similar lamps which would be adapted for economical use in large numbers in multiple arc, he would have known from his knowledge of the laws of electricity what changes should be made in the dimensions of the burner to adapt the lamp for its new use. III., 1542, **6166-7.**

BURNER OF CARBON—(*Continued*):

of lamps in use is made without coiling or arranging it in such a manner as to restrict the radiating surface. III., 1620, **6482.**

Admits that, at date of patent in suit, if he had been told to make a carbon thread lamp with an all glass chamber and with parallel leading wires passing into the same side of the chamber, he would have connected the carbon thread to the leading wires as a straight strip, if of just the proper length. If it were longer, he would have bent it into a loop or arch, or if still longer, he might have given it a turn in the globe. These forms of a strip or bent piece were old, and a person would have naturally put carbon thread in these forms. III., 1624-5, **6496-9.**

The closeness of coiling of burner, shown in drawing of patent in suit, would cause no considerable restriction of radiating surface or variation in temperature between the centre and end coils. III., 1652, **6608.**

Scott's provisional specification of 1878, in describing the process of rolling paste, prior to its carbonization, into rods for electric lighting, refers to arc lighting. III., 1667, **6667.**

Pulvermacher's English patent of 1878 describes his carbon conductors in connection with arc lighting only; while, for incandescent lighting, platinum is referred to as the material for the burner. III., 1667, **6668.**

The King method of making a burner from gas-retort carbon, by cutting and filing it to shape, is not used in any commercial lamps, neither are the burners of such lamps made of this kind of carbon. III., 1699-1700, **6796-8.**

CANDLE-POWER:

One chief disadvantage of incandescent lighting to-day is that lamps deteriorate with respect to uniformity in candle-power, although this takes place slowly. III., 1506, **6024.**

In order that any two lights may be of the same candle-power under the same conditions (that is to say, if connected in multiple-arc to the same circuit and therefore if operated at the same electro-motive force), uniformity in extent of radiating surface is required. III., 1506, **6023.**

of the largest incandescent lamp of which he has knowledge is 1,500 candles. This lamp is known as the "Sunbeam" lamp. Produces one of these lamps which is broken. This particular lamp is rated at 500 candle-power, and requires 65 volts and 16 amperes. The burner is about .05 of an inch in diameter. Its calculated resistance would be 4 ohms. Thinks from appearance of the burner that it has been subjected to hydro-carbon treatment. III., 1548, **6192.**

CARBON:

Gaudiun used a process for increasing the density of his carbon articles by impregnating them with carbonizable material. III., 1514, **6055.**

The process of dipping carbon in a carbonizable solution, and afterwards re-carbonizing it, was known prior to patent in suit as a means for reducing the resistance of carbon. It tends to make the carbon of comparatively low resistance. III., 1628-9, **6512-3.**

CARBONIZATION:

Pulvermacher, in 1878, states that his carbon "rod spirals" are to be carbonized in a box filled with powdered or pulverized carbon. III., 1516, **6064.**

was done before date of patent in suit in iron boxes and in black lead crucibles. III., 1641, **6561.**

The process of packing articles to be carbonized in a carbon dust or powder was known long prior to patent in suit. III., 1650, **6597.**

CENTRAL STATION LIGHTING:

Does not know that the United States (defendant) Electric Lighting Company had any central station plants prior to May, 1885, but understands that they had a number of isolated plants with lamps in multiple arc. III., 1682, **6727.**

CLAMPING:

Thinks the method of joining the carbon filament to the platinum wires prior to carbonization, which is described in patent in suit, may be new. III., 1517, **6066.**

Patent No. 335,158, granted to him February 2, 1886, describes a lamp in which the straight carbon burner is held in place by pressure between two carbon blocks or sockets. Says the joint between the burner and blocks could be improved by joining them together with sugar syrup. Carbonization would then connect the two. Admits that such a joint has never been used by himself or others in making commercial lamps. III., 1595, **6377,** and 1598-9, **6390-3.**

Has never tried to attach platinum wires to a carbon filament before its carbonization. III., 1648, **6590.**

The short platinum wires, mentioned in patent in suit, which are attached to the filament prior to its carbonization, would form good surfaces to clamp to the wires which pass through the lamp globe, and are evidently for this purpose. In the early stages of modern incandescent lighting, when metallic clamps were used, it was found desirable to provide the carbon burners with metallic ends for securing good contact in clamping. That operation had also been practiced with battery plates. III., 1648, **6591.**

CLAMPS:

The little clamps *h h*, shown in Figs. 1 and 3 of patent in suit, are manifestly for uniting the platinum wires, which are attached to the burner prior to carbonization, to the wires which pass through the glass. III., 1650, **6590.**

The difficulty which may proceed from the gases given off by carbon paste clamps is determined by their mass. Any amount of this paste which would be sufficient to make a good joint would satisfy the patent in suit. III., 1657, **6628** and 1658, **6631.**

COMMERCIAL SUCCESS:

The number of lamps used in isolated plants to-day runs up into high figures, and will approximate the total number used at the present time in multiple arc for central station work with all those systems of distribution which use the lamps in multiple arc. Earlier in the business of modern incandescent lighting the isolated plants contained the larger number of lamps. III., 1677-8, **6705-9.**

CONDUCTOR:

Other things being equal, the cross-section of a conductor increases as the distance, and its weight as the square of the distance of the lamps from the dynamo. III., 1531, **6122.**

If the distance from a lamp to the dynamo is great, and it is desired to have a small conductor, a small current must be used. But it is necessary, in order to supply the requisite energy to the lamp with this small current, that a high electro-motive force be used and that the lamp be of high resistance. III., 1532, **6125-6.**

CURRENT:

If the distance from a lamp to the dynamo is great and it is desired to have small conducting wires, a small current must be used. This necessitates a high electro-motive force and lamp of high resistance. III., 1532, **6125-6.**

A lamp of given resistance, which calls for a certain strength of current to operate it, will require conductors of only one-fourth the weight of those required by another lamp which has been so reduced in resistance as to require double that current; hence the importance of keeping down the amount of current required by lamps in a multiple arc system of distribution, and of supplying the energy to the lamps with a high enough electro-motive force to pass the moderate current required through the resistance of the lamps. III., 1534, **6135.**

Says that Edison's dynamo, made in 1879, would give a steady current if driven at uniform speed, and that the question of obtaining steady currents was one of steam engineering and not of electrical engineering. III., 1687-8, **6746-9.**

DISTRIBUTION OF ELECTRICITY:

Other things being equal, the cross-section of the conducting wires increases as the distance, and their weight as the square of the distance of the lamps from the dynamo. III., 1531, **6122.**

DURABILITY:

"There seems to be little doubt that an incandescent electric lamp of moderate permanency is a mechanical possibility. Whether the lamp in question (the speaker is referring to Edison lamps made in December, 1879, or January, 1880) answers all the requirements in this case is, of course, for the future to determine. It would seem, indeed, that a consideration of facts long in possession of electricians and others points to the construction of a practically permanent incandescent lamp as a possibility. The earlier lamps were short-lived; those succeeding were more lasting. The element of permanency seemed to have been gradually introduced, and the results claimed by Mr. Edison point in the same direction. Whether any new departures have yet to be taken to secure a practical, enduring lamp cannot as yet be determined" (Remarks on Outerbridge's lecture on "The Edison Electric Light," delivered at the Franklin Institute, January 21, 1880). VI., 4221.

DYNAMOS:

in their improved forms began to be brought out about 1876. The Gramme machine was invented about 1869, but was not applied to industrial uses until several years later. The Siemens machine was invented about 1873, and shown in a completed or more or less perfected state in 1878 at the Paris Exhibition. III., 1547, **6185.**

From 1870 I was closely interested in the development of arc lights, and from 1873 or '4 equally interested in development of dynamos, believing that there was a great future for arc lighting. I have been interested in arc lighting as a commercial business since 1879. III., 1552-3, **6205-9.**

Says that Edison's dynamo, made in 1879, would give a steady current if driven at a uniform speed, and that the question of obtaining steady currents was one of steam engineering, and not of electrical engineering. III., 1687-8, **6746-9.**

ECONOMY:

Lowering the vacuum lowers the candle-power by cooling the burner. The candle-power rapidly falls off as atmospheric pressure is reached, and the economy diminishes in like ratio. III., 1659, **6633-5.**

EFFICIENCY:

A lamp having its chambers filled with inert gas at about atmospheric pressure cannot compete with a vacuum lamp. III., 1662, **6645.**

EVAPORATION:

The lowering of the vacuum causes disintegration of the carbon burner. The presence of oxydizing gases is the worst condition to meet, and a very slight leak of such gases into the lamp chamber is detrimental. III., 1659, **6633**, and 1660, **6639.**

FILAMENT OF TAR-PUTTY:

Admits never having attempted to make a lamp by the processes described in patent in suit. While judging that it would be very difficult to manipulate tar-putty and almost impossible to coil it, he admits that he has not aided his judgment by actual experience. III., 1639-40, **6556-9.**

Never tried to coil a tar-putty filament upon or between the coils of a copper helix, and never made a spiral burner. If at date of patent in suit he had been told to wind a thread of plastic material into a spiral, the use of a mandril would have suggested itself. III., 1642, **6565-8.**

GASES:

The lowering of the vacuum by the giving off of gases is a serious difficulty in lamps of high voltage (they would also be of high resistance). It lowers the candle-power by cooling the burner, and causes disintegration of the carbon, and may give rise to vacuum discharge, which is a rapid source of disintegration. The candle-power rapidly falls off as atmospheric pressure is reached, and the economy diminishes in like ratio. With a comparatively low vacuum it is difficult to cause a vacuum discharge, but at this point the efficiency is reduced. The presence of oxidizing gases, driven out into the lamp chamber, is the worst condition to meet. A very slight leak of oxidizing gases into the lamp chamber is detrimental. III., 1658-9, **6632-5**, and 1660, **6639.**

King's patent makes no provision for removing the deleterious gases which would be given off by the carbon and the surrounding parts. III., 1700, **6799.**

HEATING DURING EXHAUSTION:

The application of heat in getting a high vacuum was known prior to date of patent in suit. In making a lamp like that described in the patent, a skillful electrician or physicist would naturally heat the lamp globe, and would also heat the burner by passing a current through it. III., 1605, **6418**, and 1606, **6423.**

Heating of the carbon and the enclosing globe for the purpose of driving air and gas out of the burner and surrounding parts was known prior to date of patent in suit.
The process is described in Sawyer-Man Patents Nos. 210,809 and 211,262, and in Edison's French patent in connection with his platinum lamp, and referred to therein as being suitable for use with carbon. III., 1606-7, **6424-7.**

HYDRO-CARBON TREATMENT:

as described in Sawyer-Man Patent No. 211,262 of 1879, does not state the requirements which would make it suitable for adjusting the resistance of filaments, although sufficient as describing a process for solidifying and diminishing the specific resistance of carbon. III., 1631, **6523.**

very rapidly lowers the specific resistance of carbon. III., 1707, **6825.**

ISOLATED LIGHTING:

The number of lamps used in isolated plants to-day runs up into high figures, and will approximate the total number used at the present time in multiple arc for central station work with all those systems of distribution which use the lamps in multiple arc. Earlier in the business of modern incandescent lighting the isolated plants contained the larger number of lamps. III., 1677-8, **6705-9.**

Would not be surprised to learn that as late as August, 1886, the Edison Company had in operation 181,463 lamps in isolated plants and 149,900 lamps in central station plants.
The first Edison plant was installed in the steamship "Columbia," in May, 1880. Does not question the fact that isolated lighting grew with fair rapidity at the hands of the Edison Company. III., 1678-80, **6710-3-6.**

Does not know that defendant company had any central station plants prior to May, 1885, but understands that they had isolated plants in which the lamps were used in multiple arc. It is possible that plants using lamps of 40 ohms resistance may have been put in operation by this company. Understands that defendant company started its business with lamps of comparatively low resistance. It is a fact that defendant company commenced to make lamps of the lower resistance and did business with these lamps arranged in large numbers in multiple arc. III., 1682-4, **6727-34.**

KING'S LAMP:

King, in his carbon lamp, intended that the burner should be made from hard carbon by filing it down to the desired shape and thinness after being cut out by sawing. III., 1545, **6178.**

King's patent does not state that the submarine lamp mentioned is not to have a mercury reservoir and column. III., 1689, **6755.**

King's patent does not state that a platinum wire is to be substituted for the copper wire *n* in the submarine lamp. III., 1696, **6783.**

The leaf form given to the King burner produces a maximum rather than a minimum radiating surface for a given resistance. The minimum surface would be obtained by making the burner into a round wire. III., 1699, **6793-4.**

KING'S LAMP—(*Continued*):

The King method of making a burner from gas-retort carbon by cutting and filing it to shape is not used in any commercial lamps; neither are the burners of such lamps made of this kind of carbon. III., 1699-100, **6796-8.**

King's patent makes no provision for removing the deleterious gases which would be given off by the carbon and surrounding parts. III., 1700, **6799.**

LAMP, ARC:

Profs. Thomson and Houston, in speaking of their vibrating arc lamp, say that "* * * our attention has been directed to the production of a system that will permit the use of a feebler current for producing an electric light than that ordinarily required; or, in other words, the use, when required, of a current of insufficient intensity to produce a continuous arc. At the same time our system permits the use of a powerful current in such a manner as to operate a considerable number of electric lamps placed in the same circuit." Then follows a description and illustration of the lamp (Thomson-Houston article in "Journal of the Franklin Institute" for Oct., 1878). VI., 4119-22.

Concerning their induction system for producing reversed currents for operating their vibrating arc lamp, Profs. Thomson and Houston say that "* * * a considerable number of secondary currents are obtained, each of which is able to operate one of our vibrating lamps. The use of a vibrating lamp admits of a wide range in the size of the currents employed. When a light of moderate intensity is desired the carbons are made of very small size and are placed in a closed glass vessel for protection from the atmosphere. * * * The variations in the intensity of the induced currents will, of course, be followed by variations in the intensity of the light emitted by the lamp" (Thomson-Houston article in "Journal of the Franklin Institute" for January, 1879). VI., 4123-4.

In their article on the Efficiency of Dynamo-Electric Machines Profs. Thomson and Houston say: "Where it is desired to produce light, the external resistance is generally that of an arc formed between two carbon electrodes; the resistance of the arc is, therefore, an important factor in determining the efficiency. To realize the greatest economy, the resistance of the arc should be low, but, nevertheless, should constitute the greater part of the entire circuit resistance. * * * It may be noted as an interesting fact that when the greatest current was flowing the resistance of the arc thereby produced was low. * * * In this latter case also the greatest amount of light was produced" (Thomson-Houston article in "The Telegraphic Journal" for January 15, 1879). VI., 4128.

In their article on the "Efficiency of Dynamo-Electric Machines," Profs. Thomson and Houston refer to the well-known method of obtaining light from incandescent platinum. They say that if the decrease of light

LAMP ARC—(*Continued*):

were proportional to the decrease of temperature, lighting by incandescence might be economical, but that unfortunately the decrease of the former is far greater than that of the latter. "It would, therefore, appear that the employment of a resistance of platinum, or other similar substance whose temperature of alteration of state" (that is to say, its melting or vaporizing temperature), "as compared with that of carbon is low, must be far less economical than the employment of the arc itself, which, as now produced, has been estimated as about two or three times less expensive than gas. Indeed, it would seem that future improvements in obtaining light from electrical currents will rather be by the use of a sufficient resistance in the most limited space practicable, thereby obtaining in such space the highest possible temperature" (Thomson-Houston article in "The Telegraphic Journal" for January 15, 1879). VI., 4129-30.

Note. The "highest possible temperature" referred to would be obtained "in the most limited space practicable" by use of an arc light.

In January, 1880, Prof. Thomson says that "There seems, indeed, to be two fields of usefulness for electric lighting: First, where large areas are to be lighted, or where a powerful white light is needed for specific purposes, the arc light is a demonstrated success, and its cheapness is a recommendation; second, illumination of small areas, as in house lighting, to which lighting by incandescence would seem to be peculiarly adapted, but the success of which rests on the permanency of the lamp and the economy of power consumed, both matters which have not as yet been sufficiently determined" (Remarks on Outerbridge's lecture on "The Edison Electric Light," delivered at the Franklin Institute January 21, 1880). VI., 4223.

I began to develop an arc-lighting system in 1876 and '7. III., 1551, **6206.**

From 1870 I was closely interested in the development of arc lights, and from 1873 or '4 equally interested in development of dynamos, believing that there was a great future for arc lighting. I have been interested in arc lighting as a commercial business since 1879. III., 1552-3, **6205-9.**

Expected with his vibrating arc lamps of 1878-9 to get smaller lights, and, as it were, divide the arc light of larger power into several lights of lesser power. The suitability of these smaller divided lights to any particular kind of lighting was a matter for subsequent determination. Had this vibrating lamp in mind for the purpose of producing small electric lights. It represents his effort to use the arc principle and apply it to smaller lights. The lamp was a failure and was never used. III., 1560, **6238**; 1561, **6243**; 1562, **6245**; 1563, **6249**; 1563, **6251**, and 1564, **6253.**

In January, 1880, at the time Outerbridge read his paper on the Edison Electric Light before the Franklin Institute, steps were taken to form a

LAMP ARC—(*Continued*):

company to introduce the arc-light apparatus devised by Thomson and Houston. Up to the fall of 1882 but few arc lamps had been sold, and manufacture of incandescent lamps by the Thomson-Houston Company began in 1885. III., 1592-3, **6365-9.**

Scott's provisional specification of 1878, in describing the process of rolling a paste, prior to its carbonization, into rods for electric lighting, refers to arc lighting. III., 1667, **6667.**

Pulvermacher's English patent of 1878 describes his carbon conductors in connection with arc lighting only, while, for incandescent lighting, platinum is referred to as the material for the burner. III., 1667, **6668.**

LAMP, INCANDESCENT:

In January, 1880, Prof. Thomson says that "There seems, indeed, to be two fields of usefulness for electric lighting: First, where large areas are to be lighted, or where a powerful white light is needed for special purposes, the arc light is a demonstrated success, and its cheapness is a recommendation; second, illumination of small areas, as in house lighting, to which lighting by incandescence would seem to be peculiarly adapted, but the success of which rests on the permanency of the lamp and the economy of power consumed, both matters which have not as yet been sufficiently determined" (Remarks on Outerbridge's lecture on "The Edison Electric Light," delivered at the Franklin Institute January 21, 1880). VI., 4223.

The Thomson-Houston Company makes series lamps, some of which are for use on circuits in series with arc lights. Produces such a lamp which requires a current of 10 amperes, gives a light of 20 candles, and has a resistance of .72 of an ohm. The burner is .04 of an inch wide, .017 of an inch thick, and 1⅞ inches long. III., 1548, **6190-1.**

The Thomson-Houston Company began to make incandescent lamps commercially about 1885, for the reason that there was a demand for incandescent lighting. At that time incandescent lighting had been made an established commercial industry by others. Says that he did not design the lamps made by his company; that he made some experiments in incandescent lamp work in 1883, and that he had complete facilities for making lamps in the fall of 1884. III., 1593-4, **6369-77.**

Patent No. 335,158, for an incandescent lamp, was granted to him and assigned to Thomson-Houston Electric Company February 2, 1886. Never has made a lamp like that described in this patent. The joint around the iron cone, where it passes through the glass walls of lamp chamber, is partly a fused and partly a cement joint. Neither the Thomson-Houston nor any

LAMP INCANDESCENT—(*Continued*):

other company uses leading wires made of iron. Platinum wire, without cement, is used altogether, as it has the same coefficient of expansion as glass, and a tight joint can be made by fusion of the glass around it. Iron leading wires, the use of which is suggested in this patent, would shrink away from the glass and would make the plastic cement a necessary addition to get a tight joint, unless a glass having some coefficient of expansion, as iron, were used. Admits that he has not discovered and made public a glass of this character. Admits that he has never tried the process of construction shown in this patent, consisting of a conical iron cone running out into a glass cone. The patent describes a straight carbon burner held in place by pressure between two carbon blocks. Says the joint between the burner and blocks could be improved by joining them together with sugar syrup. Carbonization would then connect the two. Admits that such a joint has never been used by himself or others in making commercial lamps. III., 1595-601, **6377-403.**

Patent No. 335,160, for an incandescent lamp, was granted to him and assigned to Thomson-Houston Electric Company February 2, 1886. Never has practically employed the described method of sealing in leading wires, either as applied to iron or platinum wires. Never has used the described resistance-equalizing clip, and no lamps have been commercially manufactured by the Thomson-Houston Company in accordance with this patent. III., 1601-3, **6403-9.**

Platinum or platinum-iridium are practically useless materials from which to make incandescent burners. Edison's platinum lamp was never put to practical use. III., 1663, **6651-2.**

Pulvermacher's English patent of 1878 describes his carbon conductors in connection with arc lighting only; while, for incandescent lighting, platinum is referred to as the material for the burner. III., 1667, **6668.**

Does not know that the "Sunbeam" lamp is in use in this country. III., 1701, **6804.**

Schedule of lamps made by Thomson-Houston Company. III., 1710-1, **6837-43.**

LEADING WIRES:

Patent No. 335,158, for an incandescent lamp, was granted to him and assigned to Thomson-Houston Electric Company, February 2, 1886. Never has made a lamp like that described in this patent. The joint around the iron cone, where it passes through the glass walls of lamp chamber, is partly a fused joint and partly a cement joint. Neither the Thomson-Houston nor any other company uses leading wires made of iron. Plati-

LEADING WIRES—(*Continued*):

num wire without cement is used altogether, as it has the same coefficient of expansion as glass, and a tight joint can be made by fusion of the glass around it. Iron leading wires, the use of which is suggested in the patent, would shrink away from the glass and would make the plastic cement a necessary addition to get a tight joint, unless a glass having same coefficient of expansion as iron were used. Admits that he has not discovered and made public a glass of this character. III., 1595-601, **6377-403.**

Patent No. 335,160 for an incandescent lamp was granted to him and assigned to Thomson-Houston Electric Company February 2, 1886. Never has practically employed the described method of sealing in leading wires, either as applied to iron or platinum wires, and no lamps have been commercially manufactured by the Thomson-Houston Company in accordance with this patent. III., 1601-3. **6403-9.**

The short platinum wires mentioned in patent in suit which are attached to the filament prior to its carbonization, would form good surfaces to clamp to the wires which pass through the lamp globe, and are evidently for this purpose. In the early stages of modern incandescent lighting, when metallic clamps were used, it was found desirable to provide the carbon burners with metallic ends for securing good contact in clamping. That operation had also been practiced with battery plates. III., 1648, **6591.**

The little clamps *h h*, shown in Figs. 1 and 3 of patent in suit, are manifestly for uniting the platinum wires, which are attached to the burner prior to carbonization, to the wires which pass through the glass. III., 1650, **6590.**

MULTIPLE ARC:

If, at date of patent in suit, a skilled person had been shown a lamp like the Edison "Municipal" lamp, and had been asked to make similar lamps which would be adapted for economical use in large numbers in multiple arc, he would have known from his knowledge of the laws of electricity what changes should be made in the dimensions of the burner to adapt the lamp to its new use. III., 1542, **6166-7.**

Defendant's zigzag paper lamp, which has a hot resistance of 80 ohms, and the M lamp, with a hot resistance of 40 ohms, would be available for use over limited areas on simple multiple arc circuits. Thinks the first-mentioned lamp could be so used over areas one-eighth and one-quarter of a mile from the central station, and the M lamp at half these distances. For isolated lamps, say within a building, the M lamp is adapted for use in multiple arc in large numbers from the same dynamo. III., 1680-2, **6719-22-5.**

MULTIPLE ARC—(*Continued*):

Understands that defendant company had isolated plants in which the lamps were used in multiple arc prior to May, 1885. It is possible that plants using lamps of 40 ohms resistance may have been put in operation by this company. Understands that defendant company started its business with lamps of comparatively low resistance. It is a fact that this company commenced to make lamps of the lower resistance, and did business with these lamps arranged in large numbers in multiple arc. III., 1682-4, **6727-34.**

MULTIPLE SERIES:

The Edison "Municipal" lamps, which he first saw two or three years ago, are adapted for use in series and in multiple series. These two arrangements were known long prior to patent in suit as general circuit arrangements in the electrical connection of apparatus. III., 1688-9, **6752-4.**

PATENT IN SUIT:

clearly states that the coiling of the carbon filament would prevent or lessen the flicker of the light when an unsteady current was used, and that this defect would not show on a plain (uncoiled) burner if the current were steady. Does not know whether the patent contemplates that a plain burner might be used and still not be subject to flickering, if the current were steady. Thinks that the coiled form is made an important feature of the invention, and is the preferred form. As to the statement in the specification that a cotton thread properly carbonized, etc., will offer a certain resistance, while if the thread be coiled it will offer a certain other resistance, he does not know whether this indicates that the first-mentioned thread is to be coiled or not. Its form might be anything except the coiled form, from which it is distinguished. It might be doubled up in some form or other. Admits that the statements in the patent which are above referred to may refer to a plain thread arranged in some way; but that he does not find that statement in the specification. III., 1610-13, **6440-51.**

(Adjourned to meet on following day, February 18.)

On February 18 Prof. Thomson thinks these statements in the patent in suit, with reference to carbonized thread, are merely statements of experiments, and that the specification does not at that place indicate what form the first-mentioned thread is to have, or that it is to be a plain, uncoiled thread, without restricted radiating surface. Admits that this carbon thread is, from the specification, supposed to be mounted in an exhausted globe, so that a current can be passed through it; and that this was necessary in order that it might be ascertained that the carbon thread would stand the high temperature of incandescence in a vacuum, as stated in the patent. Apparently the first-mentioned thread is to be much shorter than the other, and if both were coiled in the same way, the second would have a much greater candle-power than the first. III., 1614-21, **6453-86.**

Admits never having attempted to make a lamp by the processes described in patent in suit. III., 1639, **6556.**

RADIATING SURFACE:

In order that any two lights may be of the same candle-power under the same conditions—that is to say, if connected in multiple arc to the same circuit, and therefore if operated at the same electro-motive force—uniformity in extent of radiating surface is required. III., 1506, **6023.**

The closeness of coiling of burner, shown in drawing of patent in suit, causes no considerable restriction of radiating surface or variation in temperature between the centre and end coils. III., 1652, **6608.**

The leaf form given to the King burner produces a maximum rather than a minimum radiating surface for a given resistance. The minimum surface would be obtained by making the burner into a round wire. III., 1699, **6793-4.**

RESISTANCE:

In their article on the Efficiency of Dynamo-Electric Machines Profs. Thomson and Houston say: "Where it is desired to produce light, the external resistance is generally that of an arc formed between two carbon electrodes; the resistance of the arc is, therefore, an important factor in determining the efficiency. To realize the greatest economy the resistance of the arc should be low, but, nevertheless, should constitute the greater part of the entire circuit resistance. * * * It may be noted as an interesting fact that when the greatest current was flowing the resistance of the arc thereby produced was low. * * * In this latter case also the greatest amount of light was produced" (Thomson Houston article in The "Telegraphic Journal" for January 15, 1879). VI., 4128.

If the distance from a lamp to the dynamo is great, and it is desired to have small conducting wires, it is necessary to use a small current. This calls for a high electro-motive and a lamp of high resistance. III., 1532, **6125-6.**

After saying that there is a great disadvantage in attaching the leading wires to the burner before its carbonization, as described in patent in suit, in that this method does not permit of adjusting the lamps to a uniformity of resistance (III., 1627, **6506**), the witness admits that of the two methods of doing this—by means of hydro-carbon treatment and by cutting of the ends of the burner before it is attached to the leading wires—the Edison Company does not use the hydro-carbon process. He also admits that defendant's commercial lamps in evidence have enlarged ends which preclude the possibility of adjustment of their resistance by the last-mentioned process of cutting. He states that if these methods of adjustment are not used, the lamps have to be sorted for commercial use into groups or batches, in each of which the lamps do not vary widely in resistance, and that the Edison Company pursues this practice. Admits, however, that the other makers of lamps who do use the before-men-

RESISTANCE—(*Continued*):

tioned methods of adjustment, are also practically compelled to sort their lamps into groups. Thinks that the Thomson-Houston Company sort their lamps into two or three groups. Finally admits that, broadly speaking, sorting to some extent is always necessary, but that, with the aid of the hydro-carbon process, it would have to be done to a less degree. III., 1632-9, **6525-54.**

RESISTANCE, SPECIFIC:

of carbonized cotton thread, mentioned in patent in suit, would be high, whether it were plain or coiled into a spiral. III., 1624, **6496.**

The process of dipping carbon in a carbonizable solution and afterwards re-carbonizing it, reduces its resistance and changes its nature, tending to make it of comparatively low resistance. Such processes were known before date of patent in suit as means for reducing the resistance of carbon. III., 1628-9, **6512-3.**

Hydro-carbon process described in Sawyer-Man patent No. 211,262 of 1879, does not state the requirements which would make it suitable for adjusting the resistance of filaments, although sufficient as describing a process for solidifying and diminishing the specific resistance of carbon. III., 1631, **6523.**

Taking Prof. Barker's figures for the comparative resistance of platinum and carbon when cold as being 1 to 250, the specific resistance of incandescent carbon would be 15 times that of incandescent platinum. III., 1704, **6815.**

The object of the patent in suit is to use in the lamp the products of carbonization having a high specific resistance. Hydro-carbon treatment very rapidly lowers the specific resistance of carbon. III., 1707, **6825**

SERIES:

The Thomson-Houston Company makes series lamps, some of which are for use on circuits in series with arc lights. Produces such a lamp which requires a current of 10 amperes, gives a light of 20 candles and has a resistance of .72 of an ohm. The burner is .04 of an inch thick, .017 of an inch wide and 1¾ inches long. III., 1548, **6190-1.**

The Edison "Municipal" lamp, which he first saw two or three years ago, is adapted for use in series and in multiple-series. These two arrangements were known long prior to patent in suit as general circuit arrangements in the electrical connection of apparatus. III., 1688-9, **6752-4.**

SHAPING:

King, in his carbon lamp, intended that the burner should be made from hard carbon by filing it down to the desired shape and thinness after being cut out by sawing. III., 1545, **6178.**

The carbonized cotton thread, mentioned in patent in suit, would be of high specific resistance whether plain or coiled into a spiral. III., 1624, **6496.**

Admits that, at date of patent in suit, if he had been told to make a carbon-thread lamp with an all glass chamber and with parallel leading wires passing into the same side of the chamber, he would have connected the carbon thread to the leading wires as a straight strip if of just the proper length. If it were longer, he would have bent it into a loop or arch, or if still longer he might have given it a turn in the globe. These forms of a strip or bent piece were old, and a person would have naturally put carbon thread in these forms. III., 1624-5, **6496-9.**

Scott's provisional specification of 1878, in describing the process of rolling a paste, prior to its carbonization, into rods for electric lighting, refers to arc lighting. III., 1667, **6667.**

The King method of making a burner from gas-retort carbon by cutting and filing it to shape is not used in any commercial lamps, neither are the burners of such lamps made of this kind of carbon. III., 1699-100, **6796-8.**

SUBDIVISION:

Prof. Thomson and Houston, in speaking of their vibrating arc lamp, say that "* * * our attention has been directed to the production of a system that will permit the use of a feebler current for producing an electric light than that ordinarily required; or, in other words, the use, when required, of a current of insufficient intensity to produce a continuous arc. At the same time our system permits the use of a powerful current in such a manner as to operate a considerable number of electric lamps placed in the same circuit." Then follows a description and illustration of the lamp (Thomson-Houston article in Journal of the "Franklin Institute" for Oct., 1878). VI., 4119-22.

Concerning their induction system for producing reversed currents for operating their vibrating arc lamps, Profs. Thomson and Houston say that "* * * a considerable number of secondary currents are obtained, each of which is able to operate one of our vibrating lamps. The use of a vibrating lamp admits of a wide range in the size of the currents employed. When a light of moderate intensity is desired the carbons are made of very small size and are placed in a closed glass vessel for protection from the atmosphere. * * * The variations in the intensity of the induced currents will, of course, be followed by variations in the

SUBDIVISION—(*Continued*):

intensity of the light emitted by the lamp" (Thomson-Houston article in "Journal of the Franklin Institute" for January, 1879). VI., 4123-4.

In their article on the "Efficiency of Dynamo-Electric Machines," Profs. Thomson and Houston refer to the well-known method of obtaining light from incandescent platinum. They say that if the decrease of light were proportional to the decrease of temperature, lighting by incandescence might be economical, but that unfortunately the decrease of the former is far greater than that of the latter. "It would, therefore, appear that the employment of a resistance of platinum, or other similar substance whose temperature of alteration of state" (that is to say, its melting or vaporizing temperature), "as compared with that of carbon is low, must be far less economical than the employment of the arc itself, which, as now produced, has been estimated as about two or three times less expensive than gas. Indeed, it would seem that future improvements in obtaining light from electrical currents will rather be by the use of a sufficient resistance in the most limited space practicable, thereby obtaining in such space the highest possible temperature" (Thomson-Houston article in "The Telegraphic Journal" for January 15, 1879). VI., 4129-30.

Note. The "highest possible temperature" referred to would be obtained "in the most limited space practicable" by use of an arc light.

In January, 1880, Prof. Thomson said that "Edison gets eight of his lights per horse-power; but those who have not given attention to the subject will say: But when all the improvements are made, may not sixteen per horse-power be obtained? We say no; it is impossible to obtain sixteen lights of equal power to the eight, even with the best machinery and under the most favorable conditions. The reason is that the best energy given out in the eight lamps, as at present used, nearly equals a horse-power, and we cannot recover in the lights more power than we employ; not, indeed, more than sixty to eighty per cent. is recovered. Eight lights per horse-power seem to be all that are obtainable without lowering the candle-power of each * * *" (Remarks on Outerbridge's lecture on "The Edison Electric Light," delivered at the Franklin Institute January 21, 1880). VI., 4222.

Note. If Prof. Thomson had been in a position to assume the radiating surface of the burner to be diminished and its temperature and incandescence increased, he would have seen that, theoretically at least, it would be possible to get sixteen lights per horse-power in place of the eight, and that to get more than the eight lights it would not be necessary to lower their candle-power.

Uniformity of structure and of operation of electric lamps is essential to subdivision. It is the life of a multiple arc system of lighting such as is indicated in patent in suit, and must be attained before such a system can be practically useful. With gas lighting the element of variation is present by turning on more or less gas to the burner; but, with the electric

THOMSON, Prof. Elihu.

SUBDIVISION—(*Continued*):

lamp, this element of variation is absent, the quality and quantity of the light depending not only on the amount of current supplied, but also upon the radiating surface and temperature of the burner, and if the latter varies in the different burners in use in a multiple arc system at normal electro-motive force, it is a variation not within control. Hence uniformity of radiating temperature or of radiation per unit of surface is essential. One chief disadvantage of incandescent lighting to-day is that lamps deteriorate with respect to uniformity in candle-power, although this takes place slowly. III., 1506-7, **6021-5.**

The term "subdivision of the electric light" never assumed an electric light as a thing to be cut up or subdivided, but rather the delivery of electric energy to produce a number of lights. It was rather a multiplication than a subdivision. III., 1519, **6076.**

Expected with his vibrating arc lamp of 1878-9 to get smaller lights, and, as it were, divide the arc light of larger power into several lights of lesser power. The suitability of these smaller divided lights to any particular kind of lighting was a matter for subsequent determination. He had this vibrating lamp in mind for the purpose of producing small electric lights. It represents his effort to use the arc principles and apply it to smaller lights. The lamp was a failure and was never used. III., 1560, **6238;** 1561, **6243;** 1562, **6245;** 1563, **6249;** 1563, **6251,** and 1564, **6253.**

VACUUM:

The lowering of the vacuum by the giving off of gases is a serious difficulty in lamps of high voltage (they would also be of high resistance) It lowers the candle-power by cooling the burner, and causes disintegration of the carbon, and may give rise to vacuum discharge, which is a rapid source of deterioration. The candle-power rapidly falls off as atmospheric pressure is reached, and the economy diminishes in like ratio. With a comparatively low vacuum it is difficult to cause a vacuum discharge, but at this point the efficiency is reduced. The presence of oxydizing gases, driven out into the lamp chamber, is the worst condition to meet. A very slight leak of oxydizing gases into the lamp chamber is detrimental. III., 1658-9, **6632,** and 1660, **6639.**

A lamp having its chambers filled with inert gas at about atmospheric pressure cannot compete with a vacuum lamp. III., 1662, **6645.**

King's patent makes no provision for removing the deleterious gases which would be given off by the carbon and surrounding parts. III., 1700, **6799.**

THOMSON, Sir William:

States, in 1879, that he is Professor of Natural Philosophy in the University of Glasgow, and was lately President of the Royal Society of Edinburgh: that he is a Fellow of St. Peter's College, Cambridge, and has devoted much time to the science and practical applications of electricity. VI., 4118.

Testifies, in 1891, that he has been Professor of Natural Philosophy in the University of Glasgow for the past 44 years; that he is a Fellow of the Royal Societies of London and Edinburgh, a member of the (British) Institution of Civil Engineers and of the (British) Institution of Electrical Engineers; has been twice President of the Royal Society of Edinburgh and of the Institution of Electrical Engineers; was for several years member of Council of the Institution of Civil Engineers; is at present President of the Royal Society of London; is one of the eight foreign associates of the French Academy of Sciences, and an honorary member of the American Institution of Electrical Engineers and of other scientific societies in America and Europe (Trenton "feeder" suit). VII., 5216-7, **12858-61.**

DYNAMOS:

I am not acquainted with any publication prior to Upton's article in "Scribner's Magazine" for February, 1880, in which a dynamo is described which could be used to generate electricity to be supplied from one central station to a large number of lamps connected in multiple arc and distributed over a wide area by means of the "feeder" system of distribution. The dynamo referred to is suitable for operating incandescent lamps in multiple arc (Trenton "feeder" suit). VII., 5253-5, **13007-13.**

EFFICIENCY:

The economy with which incandescent lamps may be operated has increased very much during the last five or six years, owing to the greater efficiency of the lamps manufactured (Trenton "feeder" suit). VII., 5265, **13054.**

ELECTRO-MOTIVE FORCE:

A variation of electro-motive force of 5 per cent. on different parts of a circuit would be quite allowable with the older modern lamps like the original Edison lamp. A variation of this amount would cause a change of about one candle in the illuminating power of a 16 candle-power lamp. A variation of more than 2 or 3 per cent. would be a considerable evil and source of loss with the modern Swan-Edison lamp (Trenton "feeder" suit.) VII., 5229, **12910-11.**

ELECTRO-MOTIVE FORCE—(*Continued*):

Prior to 1880 I knew that, with a number of current-consuming devices connected in multiple arc between two conductors, the pressure could be more nearly equalized throughout the circuit by increasing the size of the conductors. Many well-informed electricians had exceedingly vague and erroneous notions on this subject. A few people knew it, but everyone was thinking of connections in series, in which there is equality of current through the whole series whatever the size of the wire. I know of no others than Lane-Fox and Edison who, prior to 1880, showed in any published paper a statement of any knowledge of differences of pressure at different points of a multiple arc system (Trenton "feeder" suit) VII., 5239-40, **12952-4.**

GEISSLER TUBES:

Air is "one of the best, although not the strongest of insulators" ("Electrostatics and Magnetism," 1872). VI., 4389.

LAMP, ARC:

In March, 1879, the idea of using arc lamps was general if not universal (Trenton "feeder" suit.) VII., 5223, **12888.**

LAMP, INCANDESCENT:

In March, 1879, incandescent electric lamps were not generally known to be practically available for ordinary electric lighting (Trenton "feeder" suit) VII., 5223, **12888.**

If, in the latter part of 1879, a friend had asked my advice as to how he should proceed to light a house with 500 incandescent lamps, I should certainly have advised him against so doing, as no incandescent lamp was known at that time, which could possibly have given a satisfactory result (Trenton "feeder" suit). VII., 5248, **12988.**

I am not acquainted with any publication prior to Upton's article published in "Scribner's Magazine," for February, 1880, in which a lamp is described which could be used in large numbers in multiple arc, and over wide areas in connection with a "feeder" system of distribution supplied from one central station. So far as I know, Upton's article was the first to make lamps of this character publicly known. They certainly were not generally known in England to the best engineers and electricians at the time of the Parliamentary Commission in 1879 (Trenton "feeder" suit). VII., 5253-5, **13007-13.**

Early in 1880, nothing was known of the possibility of a practical, useful incandescent lamp (Trenton "feeder" suit). VII., 5260, **13036.**

LANE-FOX'S PATENTS:

Lane-Fox's patent of 1878 suggested the possibility of an incandescent light of 100 volts (of high total resistance), but did not show how to realize it successfully in practice (Trenton "feeder" suit). VII., 5249-50, **12992-3.**

Early in 1880 there was nothing to prove any practical value in what Lane-Fox had published, and nothing was known of the possibility of a practical, useful incandescent lamp (Trenton "feeder" suit). VII., 5260, **13036.**

MULTIPLE-ARC:

In March, 1879, no method was known for maintaining uniform difference of potential at the terminals of whatever lamps might be used (in multiple arc). Incandescent lamps were not at that time generally known to be practically available for ordinary electric lighting (Trenton "feeder" suit). VII., 5223, **12888.**

"I know of no others than Lane-Fox and Edison who, prior to 1880, showed in any published paper or statement any knowledge of differences of pressure at different points of a multiple arc system" (Trenton "feeder" suit). VII., 5240, **12954.**

RESISTANCE:

In the latter part of 1879 the possibility of an incandescent light of more than five or ten volts was not known, and it certainly was not contained in any published document, I believe except in Lane-Fox's 1878 patent, which suggested the possibility of an incandescent light of 100 volts, though it did not show how to realize it successfully in practice (Trenton "feeder" suit). VII., 5249, **12992.**

Note. The low voltage of five or ten volts, above mentioned, means low total resistance, and the 100 volts means high total resistance.

SERIES:

In testifying before the Parliamentary Committee in the spring of 1879, suggestions were made by myself and other witnesses as to the regulation of electricity for electric lighting, but they had reference rather to regulation for uniform strength of current (lamps in series) than for uniform potential (lamps in multiple arc), the idea of using arc lamps being then general, if not universal. The general idea was to provide uniform current through a series of arc lamps in circuit, and to provide for uniformity of current in the event of one lamp or more being cut out of the circuit. No light whatever was thrown by any of the witnesses upon the question of maintaining uniform differences of potential at the lamps used over any considerable area, whether distant from or near to the source of supply (Trenton "feeder" suit). VII., 5223-4, **12888-91.**

Early in 1880, engineers—myself among them—with the exception of Lane-Fox and Edison, thought only of lamps being arranged in series (Trenton "feeder" suit). VII., 5260, **13036.**

SUBDIVISION:

"We have no scientific law of the economy of the electric light in different degrees of division and concentration: but practical and theoretical guesses seem to agree in making the economy much less when we spend the same quantity of energy, for example in ten feebler lights, than when we spend it in one strong light: when we do this we do not get nearly one-tenth part of the whole light by any of the plans hitherto in use." There is nothing in the mathematical discussion of the question that should render the reduction necessarily as the square or the cube, " * * * it is quite possible that a plan of using electric energy for light might be found, and may yet be found, in which ten feebler lights will give a sum of light equal to that obtainable by the same energy in one concentrated light" (Testimony before the Parliamentary Committee on Lighting by Electricity, May 23, 1879). VI., 4118.

In and during the year 1880, if an electrician had been called upon to devise means for lighting a considerable area, without making it necessary to use conductors of enormous size, he would have divided the area into such comparatively small districts of consumption—each provided with its own central station with steam engines and dynamos—as would enable him to obtain a sufficiently uniform voltage (*i. e.*, uniform potential with lamps in multiple arc) throughout each district for the good working of the lamp. Edison's invention ("Feeder" system of electrical distribution—Patent No. 264,642) for supplying a pair of separate conductors for each one of these subdivisions of the large area to be lighted solves the problem (of lighting a large area from one central station). The subject (subdivision) had been much discussed so far as subdividing the electric light to give numerous small lights suitable for domestic lighting, &c., was concerned; but the special requirements of the incandescent lamp, according to which differences of pressure (electro-motive force) of more than two or three per cent. would be a considerable evil and source of loss, and differences of ten or fifteen per cent. quite intolerable, presented quite a new problem (when a large area was to be lighted from one central station) (Trenton "feeder" suit). VII., 5228, **12906-8.**

A system of multiple arc distribution for supplying, from one central station, a large number of incandescent lamps spread over such a wide area that the variation in electro-motive force was a difficulty which had to be overcome, and which was overcome by connecting the lamps to sufficiently large lamp supply or consumption circuits, the latter, in turn, being fed and regulated, as to pressure only, from the central station through special conductors or "feeders" to which no current consuming devices were directly connected—was a means of solving the difficulty incident to the distribution of electricity to large numbers of lamps over a considerable area, at equal pressures, and with reasonable economy of conductors, which did not occur to myself, nor, as I believe, to any of the other electricians who testified before the Parliamentary Committee in 1879. The printed report of the committee shows that Mr. Conrad

SUBDIVISION—(*Continued*):

Cooke, in considering the question of lighting and extinguishing lamps, contemplated the use of incandescent lamps in series; that Mr. Deacon said at that time, that the lights used for public illumination (arc lights) are divided into series; and that Mr. Woodall said only a limited number of lights can be put upon one circuit. My own testimony was in reference to arc lights only, to be preferably arranged in series. I had no idea leading towards the practical realization of a system for supplying many lamps, distributed over wide areas, from one central station. In October, 1880, Mr. Swan said: "The only way of avoiding this waste of energy without abandoning the idea of small units of light would be either to employ enormously thick conductors, or have a very limited area supplied from one source." This was said with reference to Mr. Edison's plain multiple arc system. In November, 1882, Dr. C. W. Siemens said that to avoid the use of enormously thick conductors, "He would limit the area of a densely populated district to one-quarter of a square mile, notwithstanding other individuals of high standing in electrical circles held that areas of from one to four square miles could be worked to advantage" (Trenton "feeder" suit). VII., 5229-33, **12912-25.**

"This statement (of Prof. Forbes) is altogether in accordance with what is proved by the other evidence I have given that Mr. Edison's feeder method was a new solution of a problem (the supplying of a large number of lamps over wide areas from one central station) on which many electricians had worked without finding it * * *" (Trenton "feeder" suit). VII., 5238, **12948.**

When it became known two or three years after the early part of 1880, that a large variation in the pressure on different parts of a circuit would be fatal to the lamps, Sir William Siemens and Mr. Crompton, and, I believe, almost all engineers in Great Britain, thought it impracticable to carry out a system of electric lighting through any larger district than would allow a sufficiently even voltage for the good working of the lamps without an intolerably heavy expenditure for copper (Trenton "feeder" suit). VII., 5264-5, **13052-3.**

WATER AND GAS ANALOGIES:

The analogies known prior to 1880 between the flow of gas and water and of electricity, were not sufficient to teach electricians that electricity could be successfully distributed over considerable areas to incandescent lamps by means of distributing lamp circuits, connected to the central station by means of independent "feeder" circuits, so as to maintain a uniform candle-power throughout the system. To make a proper working analogy, the gas or water pipe must be filled with a porous or spongy material, through which the amount of gas or water which would percolate would be in simple proportion to the pressure, as is the flow of

6

THOMSON, Sir William.

WATER AND GAS ANALOGIES—(*Continued*):

electricity in a conductor. In reality the flow of gas or water in a pipe is in proportion to the square root of the pressure. The flow of gas is obstructed by valves, bends, elbows, differences of level, and by the stop-cock of the burner, for which there is no analogy in electricity. The only object of pressure in the case of gas is to bring it to the place of consumption, and the efficiency of the gas is not dependent on its pressure but on its combustion, and it is remarkable, in contrast to the action of electricity, that it gives better results at a low pressure, while, with the electric light, the efficiency of a certain quantity of electricity depends wholly on its pressure (Trenton "feeder" suit). VII., 5235-6, 12933-38.

TRANT, William.

SUBDIVISION:

After giving some account of the old lamps, the writer says: "How is it that light by incandescense has always proved such an utter failure? It has had a period of thirty-three years in which to develop; it has been divided into various lesser lights, numbering from two to two hundred; and it has arrested the attention and taxed the skill of the greatest electricians in the world. How is it that it is obliged to give way to light by the voltaic arc? The answer is at hand. The light by incandescence can only be obtained and divided by a great sacrifice of light and power. This is imperative from the fundamental principles of electrical science." After stating that the light diminishes as the square of the number of lamps among which the current is divided, the writer says: "When this law is borne in mind, and when it is also remembered that to produce the electric light by incandescence at least one-half of the current is lost, it will easily be imagined what a wasteful light it is." In conclusion he states that "It will be seen then from what has been above stated that the production and the divisibility of the light by incandescence is a very wasteful process; so wasteful, indeed, as to render its practical application impossible for general lighting. If, therefore, all Mr. Edison has to announce to the world (the announcement of his platinum lamp is referred to) is that he has succeeded in dividing an incandescent light, and the announcement that such is so is made on authority, his discovery amounts to very little. Both the light and its divisibility were discovered long ago. It will easily be seen that it is not in that direction that any great practical results can be obtained. The voltaic arc supplies the only divisible light of any utility and economy, and it is in its development that any real progress must be looked for (Letter on "The Divisibility of the Electric Light," November 21, 1878). VI., 4150-2.

TYNDALL, Prof. John:

states, in 1879, that he is Professor of Natural Philosophy in the Royal Institution, and the successor of Faraday. VI., 4109.

LAMP, INCANDESCENT:

Says that he has paid attention to the experiments being conducted by Mr. Edison, "and although one sees very serious difficulties in his way, one would be hardly entitled to say that he will not overcome those difficulties; but I do not know that up to the present time he has overcome them. * * * I am afraid, as regards public illumination, incandescence will not do; the expenditure would be too great. * * * I believe that the waste of electricity would be inordinate with a continuous conductor" (Testimony before the Parliamentary Committee on Lighting by Electricity, April 25, 1879). VI., 4110-1.

UPTON, Francis, R.

General Manager and Treasurer of the Edison Lamp Company. Has been engaged in the manufacture of lamps for about ten years in connection with this company.

ART, HISTORY OF:

Development of electric lighting and of Edison's work given (Article in "Scribner's Magazine" for February, 1880). VI., 4191–4204.

BURNER:

"The objections to platinum lay in its great cost and rarity; and the fact that its point of fusion is too low to insure its successful use as the source of light" (Article in "Scribner's Magazine" for February, 1880). VI., 4192.

BURNER OF CARBON:

In the course of Mr. Edison's experiments with the telephone, threads of carbon were made. He had these tested, and found the resistance very high. This suggested to him the possibility of successfully making high resistance carbon lamps. He, with the assistance of Mr. Batchelor, made a large number of lamps with carbon filaments. Frances Jehl and I tested one of first successful paper carbon loops, and found the resistance about 140 ohms cold. After repeated burnings and testings, we found there was no wasting away of the carbon (Interference Record). V., 3239–40

CARBON:

I have had some experience in carbonizing ordinary blotting paper. Carbons made from blotting paper are easily broken and not as durable as carbons made from compressed paper (Interference Record). V., 3244.

The lamps manufactured at the lamp factory are substantially like the Edison Interference Lamp, except that bamboo is used in a large number instead of paper, for the illuminating conductor, on account of the ease of manipulating it. On account of the difficulty of procuring paper of even thickness, and because the fibres of bamboo are continuous in the direction in which the current flows, bamboo is superior to paper for an incandescent conductor. As to resistance, they are practically the same, so far as their illuminating properties are concerned. One or two per cent. of the lamps manufactured by me are fitted with carbonized paper conductors (Interference Record). V., 3249.

CLAMPING:

The resistance of the Sawyer Interference Lamp being one ohm, and the clamp, as in the Edison Interference Lamp, being one ohm, one-half the energy expended in the lamp would be consumed in the clamp, while the Edison lamps, having 100 ohms resistance, only $\frac{1}{101}$ of the total energy will be consumed in the clamps (Interference Record). V., 3247.

COMMERCIAL SUCCESS:

"No successful light by incandescence had, however, been produced when Mr. Edison began his experiments" (Article in "Scribner's Magazine" for February, 1880). VI., 4193.

CONDUCTORS:

"* * * the objection to all known methods was that the conductors necessary to the supply of any lamp then known would have been of such enormous cost and size as to be impracticable for general use" (Article in "Scribner's Magazine" for February, 1880). VI., 4192.

In 1878 Mr. Edison had me calculate the size and weight of cables necessary to carry the current to a certain number of lamps of a given resistance (my impression is 100 ohms) at various distances from the machine, so that a certain per cent. of energy in the circuit could be used in the lamps. He also had me construct tables showing the joint resistance of a number of lamps in multiple arc (Interference Record). V., 3239.

DISCOVERY:

From calculations that I made for him, Mr. Edison concluded that to make a successful lamp it should have in the neighborhood of 100 ohms resistance. He tried a number of devices for obtaining this resistance from metal wire. In the course of his telephone experiments, threads of carbon were made, and these gave high resistance on testing. This suggested to him the possibility of making high resistance carbon lamps. Frances Jehl and I measured the resistance of one of the paper carbon loops, and found it about 140 ohms cold. The carbon was burnt for a number of hours, and again tested, and no change found in its resistance. This was repeated several times, burning and testing until the lamp gave out. We were elated to find no change in resistance, showing that there was no wasting away of the carbon. We then felt that it was possible to make a system of electric lighting, simply by adding to the life of the lamp, which we have since done (Interference Record). V., 3239-40.

DISTRIBUTION OF ELECTRICITY:

The analogy between the multiple arc system and that of water distribution explained (Article in "Scribner's Magazine" for February, 1880). VI., 4195-6.

DURABILITY:

We have added to the life of the lamp, first, by making better clamps, so as to hold the carbon firmly and prevent arcing; secondly, by making better carbons; third, by improved methods of getting the vacuum, so as to be sure that all the lamps are well exhausted, even when the workman is not expert (Interference Record). V., 3251.

At twelve to sixteen candle-power one of the paper carbon lamps at Menlo Park lasted 1,400 to 1,500 hours. At twenty-five candles, should think such a lamp would last from 400 to 600 hours. If the paper-carbon lamps noted in the Record were skillfully made, they should last on the average 100 to 200 hours. We have tested a lamp similar to the Edison Interference Lamp at 48 candles, and it lasted about 15 hours (Interference Record). V., 3252-3.

DYNAMOS:

In September, 1879, Mr. Edison's dynamo machines were perfect enough to make us sure that if a lamp of sufficiently high resistance could be made, it could be successfully used in a system of electric lighting (Interference Record). V., 3241.

FILAMENT OF CARBON:

Account of Edison's attempts to use a carbon filament in place of a platinum wire burner (Article in "Scribner's Magazine" for February, 1880). VI., 4197-8.

GASES:

Judging from my experience with nitrogen placed in the globe around the lamp, it would be extremely difficult for a carbon to give the same light continuously for a number of hours. I tried for over a week at one time to make a paper carbon burn in an atmosphere of nitrogen, without success. When the lamp is lighted the gas inside the globe will be expanded, thrusting out the nitrogen. When cold, the outside air will be drawn in to replace the nitrogen (Interference Record). V., 3247-8.

HYDRO-CARBON TREATMENT:

In preparing our carbons for electric lamps we do not treat them electrically in the presence of hydro-carbon gas (Interference Record). V., 3249.

INVENTION:

"The contrivances of the new lamp are so absurdly simple as to seem almost an anti-climax to the laborious process of investigation by which they were reached" (Article in "Scribner's Magazine" for February, 1880). VI., 4191.

INFRINGEMENT:

As early as the middle of July, 1882, labels were placed upon the lamps

INFRINGEMENT—(*Continued*):

manufactured by the Edison Lamp Co., giving the dates of five patents under the word "Patented," the labels also having the word "Edison" upon them in red letters. About February, 1883, another label was used bearing the words "Edison's Patents." I believe that every lamp put upon the market by the Edison Lamp Company since July, 1882, has been marked as described. V., 3893-4.

LAMP CHAMBER:

I do not consider it possible to hermetically seal the Sawyer-Man perfected lamp in a glass case, preventing any air from reaching it. Unless this is done, a carbon lamp blackens the globe that surrounds it very quickly. In a lamp chamber filled with nitrogen, the gas inside when lighted will be expanded, thrusting out the nitrogen, and, when cold, the outside air will be drawn in to replace the nitrogen. Judging from the style of the lamp, I should say the gas would be very much compressed when the lamp was lighted, owing to the great amount of heat evolved in a small chamber (Interference Record). V. 3248-9.

LAMP, INCANDESCENT:

"The contrivances of the new lamp are so absurdly simple as to secure almost an anti-climax to the laborious process of investigation by which they were reached" (Article in "Scribner's Magazine" for February, 1880). VI., 4191.

In 1878, at the time of my entering Mr. Edison's employ, he was experimenting with the platinum spiral lamp with a thermal regulator (Interference Record). V., 3238.

In November, 1879, when the stable resistance of a paper carbon loop was determined, Mr. Edison produced an incandescent electric lamp, fit to commercially compete with gas (Interference Record(. V., 3241.

On December 22d, 1879, Mr. Edison gave a public exhibition of his paper carbon lamps at Menlo Park, on which occasion there were from sixty to one hundred lamps in the circuit. Lamps were also used in the houses of Mr. Edison and myself, and were burned in my house continually and without interruption for several weeks from dark until ten or eleven o'clock (Interference Record). V., 3242.

I began to manufacture paper carbon lamps especially adapted for incandescent electric lights in November, 1879, and have continued their manufacture since. One of these lamps burned 1,400 to 1,500 hours. In May, 1880, the steamship "Columbia" was fitted with about 150 of these lamps. An exhibition was given while the steamer was at the dock in New York, lighting the saloon and a number of staterooms (Interference Record). V., 3244.

LAMP, INCANDESCENT—(*Continued*):

Judging from the surface and thickness of the carbon in the Sawyer Interference Lamp, I think it might possibly last at twenty-five candles for from 5 to 100 hours. The surface is twice as great as the surface of the Edison interference lamp. Since the economy of a lamp is inversely as the surface, it would take more power to obtain the same light from the Sawyer than from the Edison lamp. The resistance of the carbon shown in the drawing must be in the neighborhood of one ohm at the most. This renders the lamp totally uncommercial, owing to the enormous loss there must be from conduction through the clamps. If the clamp has a resistance of one ohm, one-half of all the energy used in the lamp will be lost in the clamps. In the Edison lamp, resistance 100 ohms, only $\frac{1}{101}$ of all the energy will be lost in the clamps. Besides this, the increase of the size of the carbon allows more heat to be conducted from it to the clamps. As a result, I should judge it would be impossible to seal the lamp, unless some device were used to dissipate this heat, making the lamp very large and clumsy (Interference Record). V., 3246-7.

I do not think the perfected lamp made by Sawyer-Man is a practicable lamp. The first objection is its low resistance. Besides the heat at the clamps, owing to the large currents that would have to be employed to give out sufficient energy for light from a small resistance, there would be a great deal of trouble in making the clamp last, as the tendency for arcs to spring between the clamps and the carbon would be so greatly increased. The lamp cannot be sealed so as to prevent air from reaching it. Unless this is done, a carbon lamp blackens the globe that surrounds it very quickly. From experience I should say it would be extremely difficult for carbon to give the same light continuously for a number of hours, with nitrogen placed in the globe around the lamp. I tried a week once, taking all possible precautions to insure the purity of the nitrogen, to make a carbon, composed of paper only, burn in an atmosphere of nitrogen, but without success. When lighted, the gas inside the globe will be expanded, thrusting out the nitrogen; when cold, the outside air will be drawn in to replace the nitrogen. Judging from the style of the lamp, I should say the gas would be very much compressed when the lamp was lighted, owing to the great amount of heat evolved in the small chamber (Interference Record). V., 3247-8.

The lamp produced by Welsh and put in evidence as a sample of carbonized paper lamp, purporting to have been made in accordance with descriptions in former testimony of Mr. Man and Mr. Sawyer for making practical incandescent lamps, would prove an utter failure. First, because in manufacturing the lamps, the breakage in clamping such loops would be so great as to preclude their use in competition with materials now ordinarily used. Second, owing to the irregularity of the carbon they, if it were possible to bring them to incandescence, would be so irregular as to shorten their life very materially. Third, owing to their extreme lack of elasticity it would be almost impossible to transport such lamps. (Interference Record). V., 3258-9.

PATENT IN SUIT:

Since July, 1882, all the lamps put upon the market by the Edison Lamp Company have been marked by labels giving the dates of Edison's patents, and bearing the words "Edison," or "Edison's Patents." V., 3793-4.

RADIATING SURFACE:

The surface in the Sawyer interference lamp is twice as great as that of the Edison interference lamp, and the economy being inversely as the surface, it would take more power to obtain the same light from the Sawyer than from the Edison lamp (Interference Record). V., 3246-7.

RESISTANCE:

From calculations that I made for him, Mr. Edison concluded that to make a successful lamp it should have in the neighborhood of 100 ohms resistance. He tried a number of devices for obtaining this resistance from metal wire. In the course of his telephone experiments, threads of carbon were made, and these gave high resistance on testing. This suggested to him the possibility of making high resistance carbon lamps. Frances Jehl and I measured the resistance of one of the paper carbon loops, and found it about 140 ohms cold. The carbon was burnt for a number of hours, and again tested, and no change found in its resistance. This was repeated several times, burning and testing until the lamp gave out. We were elated to find no change in resistance, showing that there was no wasting away of the carbon. We then felt that it was possible to make a system of electric lighting, simply by adding to the life of the lamp, which we have since done (Interference Record). V., 3239-40.

To the best of my recollection, Mr. Edison early in 1879 determined the prerequisite of high resistance for a successful incandescent electric light (Interference Record). V., 3240.

The resistance of the Sawyer interference lamp would be one ohm at the most. The clamp having a resistance of one ohm, one-half of all the energy expended in the lamp would be consumed in the clamp. The Edison interference lamp having a resistance of 100 ohms, only $\frac{1}{101}$ of the energy will be wasted in the clamp (Interference Record). V., 3246-7.

The resistance of the Sawyer-Man perfected lamp being low, large currents would have to be employed to give out sufficient energy for light, and I do not think that it is a practical lamp (Interference Record). V., 3247.

The resistance of bamboo is slightly less than that of paper, but this difference is not enough to affect the practical working of the lamp (Interference Record). V., 3249.

It was, to the best of my recollection, in August or September, 1879, that the carbon threads, made for the telephone experiments, were tested as to their resistance. The paper carbon loop was measured to ascertain its resistance in November, 1879 (Interference Record). V., 3250-1.

SEALING:

I should judge that it would be impossible to seal the Sawyer-Man interference lamp, unless some device were used to dissipate the heat, making the lamp very large and clumsy (Interference Record). V., 3247.

SHAPING:

I should consider that the process of "rubbing down and working out by hand the carbons," as described by Mr. Man, would be extremely difficult (Interference Record). V., 3244.

SUBDIVISION:

"The difficulty of subdivision Mr. Edison has also overcome: in his method of illumination a number of separate lights can now be supplied from the same wire, and each one, being independent, can be lighted or extinguished without affecting those near it" (Article in "Scribner's Magazine" for February, 1880). VI., 4191.

Its advantages for interior lighting explained (Article in "Scribner's Magazine" for February, 1880). VI., 4194-5.

UTILITY:

In regard to the Edison lamp: "The light is equal to gas in brightness and whiter in color; it is enclosed, and, consequently, perfectly steady; it gives up no appreciable heat; it consumes no oxygen; it yields up no noxious gases, and, finally, it costs less than gas" (Article in "Scribner's Magazine" for February, 1880). VI., 4191.

VACUUM:

After some account of the vacuum obtainable with Sprengel and Geissler pumps, the author says that "Mr. Edison's use of carbon in such a vacuum is entirely new. * * * Another purpose besides that of preventing the destruction of the carbon is served by burning it in a vacuum. Almost all the electricity is converted into light, very little being dissipated by convection or conduction as heat" (Article in "Scribner's Magazine" for February, 1880). VI., 4198.

My first recollection of Mr. Edison's attempts to obtain improved means of producing a vacuum in incandescent lamps was when he sent me to Princeton to borrow a Geissler pump. Before September 16th, 1879, pumps had been made that worked satisfactorily (Interference Record). V., 3240-1.

VANDEGRIFT, James A.

states that he was formerly in the employ of the United States (defendant) Company, and had charge of the lamp manufacturing department; that when defendant company was leased by Westinghouse Company he went into the employ of the Sawyer-Man Company, which now makes defendant's lamps. III., 1488-9, **5952-3.**

BURNER OF CARBON:

The burners of defendant company's lamps are stamped out of paper or tamadine, then carbonized, treated in a hydro-carbon vapor, and mounted in the globe, which is then exhausted. III., 1486, **5944.**

Since the latter part of 1888, defendant has made tamadine carbon burners which have not been subjected to hydro-carbon treatment at all. III., 1490, **5957.**

HYDRO-CARBON TREATMENT:

In the process employed by defendant company, the burner is placed in a vessel exhausted of air. Hydro-carbon vapor is then admitted in an attenuated condition, and the current is then passed through the burner, heating it up and depositing carbon from the hydro-carbon vapor. This treatment decreases the specific resistance of the tamadine carbon about fifty per cent., and of the paper carbon about ninety per cent. III., 1487, **5945-6.**

Defendant's burners are subjected to this treatment in a hydro-carbon vapor at about .015 of an atmosphere. The reason for having the gas so attenuated was to cause the deposit of carbon to take place within the pores of the burner rather than on the surface. III., 1488, **5950-1.**

Since latter part of 1888 defendant has made tamadine carbon burners which have not been subjected to hydro-carbon treatment at all. III., 1490, **5957.**

LAMP CHAMBER:

of defendants' lamps, made prior to May, 1889, was exhausted and sealed at all points by fusion of the glass. III., 1489, **5956.**

2

VANDEGRIFT, James A.

LAMP, INCANDESCENT:

States that he furnished the data embodied in the stipulation concerning the character of defendants' M and Zigzag lamps (sec. I., 58-9, 230-5); and that these lamps were taken from the regular stock, and are fair average samples of defendants' commercial lamps. III., 1486, **5943.**

Defendants' lamps, made prior to May, 1889, had an exhausted chamber, sealed at all points by fusion of the glass, and with platinum leading wires sealed by fusion of the glass upon them like defendants' M and Zigzag lamps in evidence. III., 1489, **5956.**

List of lamps made by defendant company in May, 1889, given, together with dimensions of their burners, etc. III., 1491, **5961-4.**

LEADING WIRES:

of defendants' lamps, made prior to May, 1889, were of platinum, and were sealed by fusion of the glass upon them like defendants' M and Zigzag lamps in evidence. III., 1489, **5956.**

RESISTANCE:

of lamps made by defendant company when hot is about half what it is when cold. III., 1489, **5955.**

RESISTANCE, SPECIFIC:

of defendants' tamadine carbon, produced by thorough carbonization in the furnace, is diminished about fifty per cent. by the subsequent hydro-carbon treatment, and that of the paper carbon about ninety per cent. This diminution in specific resistance also characterized the manufacture of carbon of the burners made prior to 1885. III., 1487, **5946-8.**

WATKINS, Alice J.:

lives in the family of Mrs. Albon Man, and is sister of Mrs. Man.

BURNER OF CARBON:

In the early spring, and again in the summer of 1878, I visited the shop in Walker Street with Mr. Man. I there saw five or six lamps having carbon burners a little longer than a half circle. I should think the carbon burners seen at Walker Street were the same shape as those I saw Mr. Man make at his house (McKeesport suit). II., 1165-6, **4660-3.**

CARBON:

The paper carbonized by Mr. Man in 1878, at Brooklyn, was in narrow strips an eighth of a yard long, and also in round rings. The sticks were straight, of different lengths (McKeesport suit). II., 1165, **4657-8.**

CARBONIZATION:

I remember Mr. Man's using in the winter and spring of 1878 a dish that he called a crucible. Into it he put bits of paper, pieces of sticks, a blackened powdered substance, then covered it and put it in the fire in the range (McKeesport suit). II., 1164, **4655.**

WILDE, Dr.:

was a member of the St. Petersburg Academy of Sciences and Director of the Central Observatory of Physics.

GEISSLER TUBES:

After referring to the efforts to subdivide the electric light, the writer says: "To this end many fruitless efforts have been made. Thus, the employment of tubes called Geissler tubes has been proposed for the division of the electric light, but experience has shown that this light was too feeble and not constant enough" (Paper on "A New Method of Electric Lighting," 1875). IV., 2113.

"It has been known also for a long time that the heating property of an electric current can be employed even without the aid of the gas, as in the luminous galvanic arc, to heat to whiteness a solid body. In accordance with this principle, thin platinum wires, which are bad conductors, have often been heated by causing them to be traversed by a strong electric current. The light obtained by this process is a good deal more fixed and more constant than the carbon (arc) electric light. It has also more power of diffusion and can be increased or diminished at will. Nevertheless it has never found a practical use because it is too feeble in comparison with its cost of production, and because, in attempting to give it more intensity, the result is usually reached of melting the platinum, which generally is not altogether homogeneous" (Paper on "A New Method of Electric Lighting," 1875). IV., 2113.

WILSON.

SUBDIVISION:

In his paper, read before the Physical Society of London, the writer considers the subject only in relation to metallic burners, for the abstract published in *Nature* reads: "He (Mr. Wilson) infers that the smaller the mass of wire the higher the temperature generated in it: therefore the mass of the wire should be diminished until the fusing point of the metal is almost attained."

He states that divisibility means to divide a single incandescent source into a number of smaller ones giving the same total illumination, and incorrectly says (as we now know) that this can be done by arranging the subdivided sources in multiple arc, provided the total mass, length and cross-section of these sources, taken together, be the same as in the original undivided source. The author anticipates that this is not entirely correct, for he says: "The objection that increased radiation from the various sources would diminish the first total of light and heat can be met by making the smaller wires still smaller than is theoretically required so as to generate more heat." If the writer's premises had been correct (as now established), so also would have been the size of the wires determined, and no empirical reduction of their size, as suggested by him, would be necessary (Paper on "The Divisibility of the Electric Light by Incandescence," of May 10, 1879). III., 1756-7, **7022-5.**

WOOD, Thomas J.:

was shipping clerk at Wallace's during the years 1876-9.

CARBON:

At the time Wallace & Sons sold out their carbon business, in 1886 or 1887, their carbons were used for arc lighting. II., 1214. **4853**

HYDRO-CARBON TREATMENT:

The carbons for electric lights sold and delivered by Wallace & Sons prior to the year 1880, were not subjected after they were baked, to treatment by immersion in a carbonaceous fluid and then rebaking. II., 1213. **4850.**

INDEX TO DIGEST.

NOTE.

The numerals not in parenthesis and those within parenthesis refer, respectively, to the page and to the number of the digest on that page. The name of the authority for the statement from which the digest is taken is printed in italics. For example, at the bottom of the first column of this page it will be ascertained that the third digest on page 423 relates, in part at least, to a statement made by J. Smith concerning the durability of Adams's lamp.

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INLEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—*Continued.*

INDEX TO DIGEST—*(Continued).*

INDEX TO DIGEST—*(Continued).*

BURNER OF CARBON—*(Continued)*:

BURNER OF CARBON—*(Continued)*:

INDEX TO DIGEST—*(Continued).*

BURNER OF CARBON—*(Continued)*:

BURNER OF CARBON—*(Continued)*:

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

BURNER OF CARBON—(*Continued*):

INDEX TO DIGEST—(*Continued*).

BURNER OF CARBON—(*Continued*):

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INLEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(Continued.)

INDEX TO DIGEST—(Continued.)

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INLEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—*(Continued)*.

INDEX TO DIGEST—*(Continued)*.

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

FILAMENT OF CARBON—(*Continued*):

FILAMENT OF CARBON—(*Continued*):

INDEX TO DIGEST—(*Continued*).

FILAMENT OF CARBON—(*Continued*):

FILAMENT OF CARBON—(*Continued*):

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—*(Continued).*

INDEX TO DIGEST—*(Continued).*

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—*(Continued)*.

INDEX TO DIGEST—*(Continued)*.

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST (*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

LAMP, INCANDESCENT—(*Continued*):

LAMP, SEMI-INCANDESCENT:

LAMP, SEMI-INCANDESCENT—(*Continued*):

LANE-FOX PATENTS:

INDEX TO DIGEST (*Continued*).

LANE-FOX PATENTS—(*Continued*):

LEADING WIRES:

LEADING WIRES—(*Continued*):

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST (*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST– (*Continued*).

INDEX TO DIGEST– (*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—*(Continued)*.

INDEX TO DIGEST—*(Continued)*.

INDEX TO DIGEST—(*Continued*).

SUBDIVISON—(*Continued*):

SUBDIVISION—(*Continued*):

INDEX TO DIGEST—(*Continued*).

SUBDIVISION—(*Continued*):

SUBDIVISION—(*Continued*):

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—*(Continued)*.

INDEX TO DIGEST—*(Continued)*.

INDEX TO DIGEST—(*Continued*).

INDEX TO DIGEST—(*Continued*).

APPENDIX.

GENERAL INDEX TO COMPLAINANT'S RECORD.

INDEX TO COMPLAINANT'S RECORD—(*Continued*).

DEPOSITIONS—(*Continued*):

INDEX TO COMPLAINANT'S RECORD—(*Continued*).

DEPOSITIONS—(*Continued*):

INDEX TO COMPLAINANT'S RECORD—*(Continued.)*

DEPOSITIONS—*(Continued)*:

COMPLAINANT'S EXHIBITS.

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—*(Continued.)*

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—*(Continued)*:

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—(*Continued*):

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—(*Continued*).

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—*(Continued)*

LETTERS AND INTERVIEWS—*(Continued)*:

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—*(Continued)*.

LETTERS AND INTERVIEWS—*(Continued)*:

NEWSPAPER AND MAGAZINE ARTICLES:

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—(*Continued*).

NEWSPAPER AND MAGAZINE ARTICLES—(*Continued*):

NOTE BOOK:

NOTICES:

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—(*Continued*).

OPINIONS OF COURT:

ORDERS OF COURT:

PATENTS:

BELGIAN PATENT.

BRITISH PATENTS.

UNITED STATES PATENTS.

INDEX TO COMPLAINANT'S RECORD (EXH'S).—(*Continued*).

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—(*Continued*).

INDEX TO COMPLAINANT'S RECORD (EXH'S.)—(*Continued*).

SCIENTIFIC LITERATURE—(*Continued*):

GENERAL INDEX TO DEFENDANTS' RECORD.

INDEX TO DEFENDANTS' RECORD—(*Continued*).

INDEX TO DEFENDANTS' RECORD—(*Continued*).

INDEX TO DEFENDANTS' RECORD—(*Continued*).

DEPOSITIONS—(*Continued*):

INDEX TO DEFENDANTS' RECORD—(*Continued*).

DEPOSITIONS—(*Continued*):

NOTICES:

ORDERS OF COURT:

PLEADINGS:

DEFENDANTS' EXHIBITS.

AFFIDAVITS AND REPORT:

AGREEMENTS AND CONTRACTS:

INDEX TO DEFENDANTS' RECORD (EXH'S)—(*Continued*).

AGREEMENTS AND CONTRACTS—(*Continued*):

APPARATUS:

BULLETINS OF EDISON COMPANY:

CARBONS:

INDEX TO DEFENDANTS' RECORD (EXH'S)—(*Continued*).

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*):

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*):

LAMPS—(*Continued*):

LAMP GLOBES:

LAMP SCHEDULES, TESTS AND MEASUREMENTS:

INDEX TO DEFENDANTS' RECORD (EXH'S)—(*Continued*).

LAMP SCHEDULES, TESTS AND MEASUREMENTS—(*Continued*):

LAMP SKETCHES:

INDEX TO DEFENDANTS' RECORD (EXH'S)—(*Continued*).

INDEX TO DEFENDANTS' RECORD (EXH'S)—(*Continued*).

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*).

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*).

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*).

PATENTS—(*Continued*):

British Patents—(*Continued*):

Canadian Patent.

French Patents.

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*).

PATENTS—(*Continued*):

Swedish Patent.

United States Patents.

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*).

PATENTS—(*Continued*):

UNITED STATES PATENTS—(*Continued*):

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*).

PATENTS—(*Continued*):

UNITED STATES PATENTS—(*Continued*):

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*).

PATENTS—(*Continued*):

UNITED STATES PATENTS—(*Continued*):

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*).

PATENTS—(*Continued*):

UNITED STATES PATENTS—(*Continued*):

PATENT APPLICATIONS:

RECORDS:

SAWYER-MAN WORKSHOP:

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued.*)

SCIENTIFIC LITERATURE:

INDEX TO DEFENDANTS' RECORD (EXH'S.)—(*Continued*).

SCIENTIFIC LITERATURE—(*Continued*):

STIPULATIONS:

SUBPŒNAS:

STIPULATIONS.

STIPULATIONS—(*Continued*).

CIRCUIT COURT OF THE UNITED STATES,

SOUTHERN DISTRICT OF NEW YORK.

IN EQUITY—No. 3445.

THE EDISON ELECTRIC LIGHT COMPANY
Complainant

vs.

THE UNITED STATES ELECTRIC LIGHTING COMPANY
Defendant.

ON LETTERS PATENT No. 223,898

DIGEST

OF SUCH OF

DEFENDANT'S PROOFS

as were not particularly referred to in Complainant's Main Digest.

EATON & LEWIS,
Complainant's Solicitors.

CLARENCE A. SEWARD,
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Of Counsel.

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ADDITIONAL DIGEST OF DEFENDANT'S PROOFS.

TABLE OF CONTENTS.

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IN EQUITY.
No. 3445.

ADDITIONAL DIGEST OF DEFENDANT'S PROOFS.

CHANDLER, PROF. CHARLES F.:

Specifies the incandescent lamps that had been made from the time of Starr (King) up to and including the date of invention of the Edison and Maxim carbon lamps, which would, in his opinion, have been **lamps capable of use with a proper system of distribution** (Trenton "feeder" suit). VII., 5162, **12,647.**

After calling attention to Edison's Patent No. 223,898 (the patent of this suit) and quoting extensively from the same, the witness quotes from a later **Edison Patent (No. 230,255** of July 20, 1880), and says of it: **"This patent describes a method for successfully manufacturing a lamp embodying the elements described as characteristic of the electric lamp of Patent 223,898,** dated January 27, 1880. It gives the necessary directions to enable the glassblower," etc., etc. These two patents describe substantially the

Edison lamp now in use, and the method employed in manufacturing it (Trenton "feeder" suit). VII., 5162-6, **12,648-61.**

The witness refers to, and quotes extensively from, **Edison Patents No. 369,280, for a multiple arc system of distribution, and No. 239,150, for a lamp. The latter patent describes the system to be used with the lamp.** [Note: *It will be well to bear in mind that Patent No. 369,280 states that, in order to avoid any appreciable variations in pressure and to insure its uniformity,* **it is necessary that the variations should be indicated at the station,** *so that the pressure may be kept uniform. To attain this result,* **pressure indicators and regulators** *are placed in the station. The* **use of galvanometer wires,** *connecting the indicators to any point of the circuit, is suggested. By* **regulating at the central station** *it becomes possible ("I am enabled") to use a small separate lamp—that is, a lamp without an individual regulator—which may be used with the exercise of no more than ordinary care or attention. Also, that Patent No. 239,150 states that: "In a system of electric lighting such as proposed by me, in which separate electric lamps devoid of regulating devices are used at the place of consumption, the entire* **regulation for all the lamps being performed at the central station, as with water or gas supply,** *it is essential that a constant electromotive force or pressure be maintained; and as in such a system the lamps are arranged upon the multiple arc or derived circuit system, it is essential that there should be a certain standard resistance in each derived circuit."*] (Trenton "feeder" suit). VII., 5167-70, **12,665-80.**

The **Edison three-volt lamps** are not intended for illumination in the ordinary sense. They are special lamps to be used as toys or for lighting Christmas trees or ladies' hair, or the interior of the mouth or stomach. They have an illuminating power of one-half of one candle, and are not used as an ordinary source of light—that is, as a substitute for a gas burner or a kerosene lamp (Trenton "feeder" suit). VII., 5175-6, **12,700-2.**

The invention described in the "feeder" patent (No. 264,642) was the most essential feature which constituted the practical solution of the problem of the subdivision of the electric light, which, prior to 1880, was regarded as extremely difficult if not impossible of solution. There were other minor features of importance, but the **distribution was the main feature of the problem.** Early in 1879, at the time the Parliamentary Committee was investigating the question, the invention described in the "feeder" patent, without any further invention by Mr. Edison or any one else, would have been regarded as a solution of the problem of subdivision (which at that time was actually regarded as very difficult if not impossible of solution), because the three necessary elements would then have been available, that is to say, incandescent lamps,

dynamos and a system of distribution. The witness then enumerates the **old lamps which would be commercially useful with Edison's feeder system,** and says that the **improvements made since 1879 have made distribution more difficult because of the delicate organization of the modern lamps.** The lamps which were known at the date of the report of the Parliamentary Committee, June 13th, 1879, would be very poor affairs compared with the lamps made now, but, without considering the commercial question, some, if not all, of those lamps could have been practically used with the "feeder" system of distribution. They were not used because much better lamps came along with the distribution system, and when practical electric lighting was adopted the improved lamps were used. Cannot say to what degree practical electric lighting would have become successful after the invention of the "feeder" system of distribution had no improvement been made in incandescent lamps. When practical lighting with a large number of lamps distributed over a considerable area was first attempted, neither the old lamps nor the old dynamos were employed. **The invention of the "feeder" system was not all that was necessary in order to solve the problem of what was called, in 1879, subdividing the electric light.** The distribution was an essential feature, but improved dynamos, meters, junction boxes, safety plugs, pressure wires, regulating devices and many other things contributed to the practical solution of the problem. **Mr. Edison was not the only one who invented improved lamps, dynamos and safety devices, but he invented a complete system of incandescent electric lighting which contained all the elements necessary for practical commercial success** (Trenton "feeder" suit). VII., 5178-82, **12,710-26.**

CROSS, PROF. CHAS. R.:

The patent in suit is incorrect in stating that in prior lamps the atmospheric air has been replaced by gases that do not combine chemically with the carbon—meaning the carbon of the burner. Incandescent lamps had been described having as perfect a vacuum as was then obtainable which would meet the requirements of the **"almost perfect vacuum"** mentioned in Edison's patent. **King's lamp** had a **Torricellian vacuum** to avoid destruction of the carbon by combination with **oxygen** of the air. The Torricellian method, when made in the manner well known at the date of King's patent, produced the best known vacuum, and quite as perfect a vacuum as that employed in incandescent lamps to-day. III., 1715, **6857-60.**

Roberts' lamp had a carbon burner placed in a high vacuum. The patent directs that the carbon is to be placed in a space not containing **oxygen** or other matter which can cause its combustion or destruction, and states that "as perfect a vacuum as can conveniently be made" is to be obtained and that "no **combustion** will ensue if the vacuum be perfect." There were also other prior lamps having a vacuum. III., 1716, **6861-3.**

The vacua contemplated by King and Roberts are of the same character as to degree as that which the Edison patent requires. The first-named inventors intended to use as perfect a vacuum as was obtainable, and, at the dates of their patents, an **"almost perfect vacuum"** would have been obtained if their directions were followed. III., 1716-7, **6864-7.**

The patent in suit is incorrect in stating that, in prior lamps, the vessel holding the burner has been composed of glass cemented to a metallic base. Sawyer-Man Patents Nos. 205,144 of June 18, 1878, and 210,809 of December 10, 1878, describe lamps having a **glass base-plate or stopper.** British patent No. 4626 of 1878, granted to **Lane-Fox,** describes a lamp having a (platinum) burner enclosed in an **all-glass globe.** The glass neck of the globe is fused about the leading wires so as to make a perfect seal. This patent states that the globe may contain a vacuum or some inert gas. Similar lamps are described in his British Patents Nos. 3988 and 4043 of 1878. **King's submarine lamp** would have a closed glass tube with platinum leading-in wires fused into its walls. Moreover, **Geissler tubes,** which had been used as fishing, mining and surgical lamps, were made entirely of glass. The light was produced by forcing electricity to overcome the **high resistance of a thin thread of rarefied gas** which was thereby made incandescent. Some forms

of **Crookes's radiometers** had a highly exhausted all-glass globe, containing a platinum wire sealed into the glass where it passed into the globe, which was heated to incandescence by passing a current through it. III., 1718-9, **6869-76.**

The patent in suit is incorrect in saying that prior lamps had a resistance of from one to four ohms only. British Patent No. 3988, of **Lane-Fox,** describes a lamp with a burner made of a very thin strip or wire, preferably of an alloy of platinum and iridium. The inventor states that the resistance and radiating surface depend upon the electro-motive force used and illuminating power desired; also that the electro-motive force should be **100 volts** that there may not be much loss from the resistance of the main conductors, and that the burner should be of fine wire to obtain a **high resistance without a large radiating surface.** This is the reason given in patent in suit for having a burner of high resistance. British Patent No. 4043 of 1878, to **Lane-Fox,** describes a lamp with a **high resistance burner** made "of asbestos or similar non-conducting material saturated or impregnated with some refractory conducting material such as carbon or iridium." His provisional specification No. 1122 of 1879 describes a lamp with a **high resistance carbon burner.** The specification states that, to produce the **light of a gas jet,** the burner should have a resistance of **300 ohms** and an electro-motive force of **140 volts** should be employed. [NOTE: *The complete specification was never filed. Prof. Cross is not strictly correct in saying that the incandescing material is made of carbon.* **A composite burner,** *made of a powdered mixture of carbon and magnesia or zirconia, lime, steatite and the like is described. It is also proposed to cover the outside of such a burner with a coating of carbon deposited by the* **hydro-carbon process.** *One bad feature proposed is in having the burner diminish in size toward the clamps in order that it shall be uniformly incandescent. This signifies that, in the inventor's mind, the* **burner is to be** *so* **rod-like** *as to lose much heat by conduction at the clamps if made of uniform diameter throughout its length. It is also to be noted that* **Lane-Fox proposes to vary the total resistance solely by changing the specific resistance** *of the material out of which the burner is made, and not by varying the length and diameter of the burner. The latter method is the only practicable way of doing this, and is the one employed in making filamentary burners by which high total resistance is obtained. As to the hermetically sealed lamp globe, it is stated that "all trace of oxygen, carbonic acid gas, water and any gas or vapor capable of attacking or affecting the material of the luminous bridge (burner) when at a high temperature must be removed." It is clear that the chemical effect, such as* **combustion,** *which the gas or vapor might have on the carbon, is what is referred to in the specification, and that the disintegrating and air-washing effect of gases were not thought of. There is* **nothing said about the use of a vacuum,** *and one might use an* **inert gas** *like nitrogen.*] Prof. Cross continues as follows: **Edison's French Patent** No.

139.110 of May 28, 1879, and his **Italian Patent** of June 23, 1879, describe a lamp of the same character as that contained in his **United States Patent No. 227,229,** granted May 4, 1880, upon an application filed April 21, 1879. This lamp has a platinum or iridium burner of about **750 ohms** resistance. The inventor states **the advantages of the high resistance** to be that the lamps may be placed in **multiple arc** without the necessity of a large current, and that conductors of moderate size may be used. **King** directs one to make the incandescing conductor "exceedingly thin," and, in the case of platinum, directions are given for producing a wonderfully thin film of that metal. It is obvious that the sole idea was to get a **suitably high resistance.** [NOTE: *The above statement by Prof. Cross is misleading. The patent does not say that the "incandescing conductor," but that "the platinum should be worked into those exceedingly thin sheets known as leaf platinum."*] The patent says that carbon burners are to be worked into "small pencils or thin plates," which means that they are to be as thin as is consistent with their stability. Whatever may have been the maximum resistance which King could have practically obtained in 1845, it is obvious that at any later date, and before Edison's patent, a person would have made the burner of a lamp of the King type as thin and fine as could be secured at the time at which he was working. Long prior to the patent in suit **processes were known whereby carbon conductors could be made having a much higher resistance than two to four ohms.** If a person had been called upon to make carbon burners which would be operative under conditions requiring a higher resistance than this, he would have been bound to use processes well known before the date of Edison's patent. III., 1719-24. **6876-93.**

The patent in suit is incorrect in stating that, because of the low resistance of prior lamps, the leading wires were necessarily so large that a glass globe could not be kept tight where the wires pass in. Commercial lamps of low resistance are in use to-day, for example, **Bernstein and Heissler lamps,** which have less than one ohm resistance; **Thomson-Houston series lamps** of three-fourths of an ohm, and **Edison municipal lamps** of from four to ten ohms. The **sealing-in** of wires, like those required in the above lamps, was practiced prior to the patent in suit in Geissler tubes. III., 1724-5. **6894-98.**

The statement in the patent in suit that "in general the attempts of previous persons have been to reduce the resistance of the carbon rod used as the burner" means that, prior to Mr. Edison, the practice had been to endeavor to lower the specific resistance of the carbon burners. This statement thus interpreted is a correct expression of the prior state of the art. In most cases prior inventors had used

burners made from **carbon like that used for arc lighting,** and this led to a lowering of the specific resistance. That the statement in patent in suit **cannot refer to total resistance** is to be judged from the fact that it would be contrary to the truth. **King and Roberts** distinctly indicate that the total resistance of their burners should be increased by using thin plates or small pencils. **Farmer,** in his Patent No. 213,643 of March 25, 1879, plainly indicates that his lamp is to have a high resistance by using "a small pencil or thin bar of carbon," or a "small thin bar of carbon." Moreover, **Sawyer and Man,** in 1878, made burners subjected to the **hydro-carbon process** which lowers the specific resistance, and Edison had probably their process in mind. **Fontaine,** in 1877, among other processes, describes that of **soaking in syrup** and subsequent recarbonization. **Edison,** in his British Patent No. 3765, of September 16, 1880, refers to this process as one resulting in a lessening of the resistance of the carbon, and that this makes it entirely **unsuited for use in incandescent lamps.** III., 1725-9, **6899-913.**

The object of Edison's invention is to subdivide the electric light to the same extent as **gas light** is subdivided by distributing the lights from a common centre over **wide districts** and to produce light in required quantities at any desired point in the district. The word "practical," in the statement that the object of the invention is to effect "the **practical subdivision** of the electric light," imports this idea. The real object of arranging the lamps in multiple arc is to enable a large number to be operated from a single source, as with gas. If a lamp were so constructed that only a few hundred could be operated from a central station, this would not be a **"large number" within the meaning of Edison's patent.** This view of the patent is confirmed by **Edison's testimony in the McKeesport suit** concerning the problem of lighting which he undertook to solve, and by his enumeration of those things which had to be done. III., 1729-31, **6914-24.**

As to the **degree of vacuum contemplated by the patent in suit,** there is but one numerical statement concerning it (**one-millionth of an atmosphere**). There is no intimation that the carbonized material referred to in this connection (cotton thread) could be used excepting in a vacuum as perfect as this, nor that any practical carbon burner could be used in a lower vacuum. III., 1732, **6925-7.**

The language of the specification, as far as it indicates anything concerning the degree of **vacuum contemplated by the second claim** of the patent in suit, would go to show that Edison had in mind a vacuum something of the order of **one millionth of an atmosphere.** III., 1732, **6928.**

The words **"made as described,"** contained in the first claim of

the patent in suit, do not refer to the reduction of the material of the burner to form before carbonization. The **specific resistance** of the burner would be the same whether it was formed before carbonization, or was cut out from material previously carbonized. The words refer to the manner of making the burner set forth in the specification, that is to say, one made by the process of simple carbonization without special treatment to lower its specific resistance; also to a **burner so coiled as to restrict the radiating surface.** They refer only incidentally to the reduction of the carbon burner to **shape prior to carbonization,** because the coiled form apparently requires that the crude material be shaped before it is carbonized. **Edison's testimony in the McKeesport suit** shows the importance of not reducing the specific resistance subsequent to carbonization, and **his British Patent No. 3765** of September 16 1880, shows the **importance of high specific resistance** resulting from simple carbonization, unaccompanied by a subsequent treatment which would tend to reduce the porosity thus produced. III., 1734-8. **6934-51.**

The **advantages of the coiled form** are that it restricts the radiating surface, from which it results that, with a given illuminating power, the length and resistance of the burner can be increased; also that a higher temperature and efficiency can be obtained for a given expenditure of energy. Moreover, the burner can be brought into a more compact form, which gives it greater mechanical strength. III., 1738-9. **6951-5.**

The concluding words, **"as set forth,"** of the first claim of the patent in suit, refer to the preceding words, **"secured to metallic wires,"** and indicate that the burner is to be secured to the platinum leading wires by means of a plastic material before the burner is carbonized. This process avoids the use of clamps, which had previously been customary. III., 1739-40. **6955-8.**

The **meaning of the term "filament" of the first claim** of the patent in suit would not be altered by substituting the word "wire." No dimensions are given which would serve to distinguish a "filament" or "wire" from the "rods" said to have been previously used. The **only distinction between a filament and a rod** seems to be one of contrasting the total resistance of the two classes of burners. From the statements upon this point contained in the specification it follows that the thing, which in the first claim is called a **"filament," must have a hot resistance of not less than 100 ohms.** Another possible, but not philosophical or tenable interpretation of the term "filament," is that it signifies a burner having a resistance sufficiently high to enable the lamp to be used in simple multiple arc in large numbers in central station lighting. **Nothing less than 100 ohms resistance would answer** in such a plant. If neither of these interpretations of the term is true, then there is nothing in the patent to

distinguish it from the carbon rods previously used. III., 1740-2. **6959-65.**

If it were proposed to define **the term "filament"** as being a burner so small that its **leading wires** could be effectively sealed into the glass chamber, then such definition of a **filament would include some of the carbons of prior lamps,** which were as small as **one millimetre** in diameter. Lamps having burners of about this diameter are in use to-day, and have platinum leading wires fused into the glass. III., 1742. **6966-7.**

In speaking of the resistance of various substances as being 100 ohms, 500 ohms, and so forth, **the patent in suit refers to their resistance when hot.** III., 1743. **6969.**

Defendants' lamps in evidence do not embody the invention of the first claim of the patent in suit. The burners are **clamped** to the leading wires, and are **not coiled.** They are not the result of simple carbonization, but have been subjected to hydro-carbon treatment, whereby their **specific resistance has been greatly reduced,** and is about the same as that of arc-light carbons and other carbons referred to in patent in suit as rods. Moreover, if the term "filament" imports either a **hot resistance of 100 ohms** or such a high resistance that the lamps can be used in **large numbers in multiple arc,** then defendants' lamps do not have such a resistance. III., 1743-4. **6970-5.**

If the **term "filament" in the second claim** of the patent in suit, is to be interpreted by reference to the *total* resistance of the burner, **defendant's M lamp and Zigzag paper lamp do not use the filament of this claim** because they do not have a hot resistance as high as **100 ohms.** III., 1745. **6977-9.**

That **Edison intended to limit himself to a burner of substantially 100 ohms** derives support from the following: In his Patent No. 369,280, of August 30, 1887, for which application was made February 5, 1880, Edison says: "A very much higher resistance—say 100 ohms—must be used in order that a number (of lamps) may be economically and successfully used in a system." III., 1745-6. **6980-1.**

In his British Patent No. 3765, of 1880, there is also language to show that **100 ohms hot is the lowest practicable resistance.** [Note: *It is to be observed that Edison also says that a resistance of 100 ohms, although preferable, may be departed from, and that it is very high when compared with that of prior lamps.*] III., 1746. **6982.**

In the interference between Edison and Sawyer & Man, the former testified that, during his early experiments in incandescent lighting, "our calculations showed us that the lamps must have at least **100 ohms**

resistance to compete successfully with gas." In the same case he said that the average **resistance of the paper carbon lamps, made in the latter part of 1879, was 100 ohms when hot.** III., 1747, **6985-7.**

Edison's British Patent No. 602, of February, 11, 1880, states that "a very high resistance, say **100 ohms, must be used**" **in a multiple arc system** of distribution. III., 1748, **6989.**

Edison's British Patent No. 2402, of June 17, 1879, the complete specification of which was filed on December 17, 1879, would indicate that at about the time the patent in suit was taken out, he considered that **a much higher resistance than 100 ohms is no more than sufficient** for a system of distribution such as is set forth in patent in suit. III., 1749, **6994.**

Another reason why all three of **defendants' lamps do not embody the invention of the second claim** is found in the concluding words of the claim, **"for the purposes set forth."** By reference to the specification **this must mean that the lamps must be adapted to be "worked in great numbers in multiple arc** without the employment of main conductors of enormous dimensions," meaning, of course, with the methods of distribution known at the date of the patent. III., 1749, **6995-6.**

The second paragraph of the **statement of invention seems to require that the burner be coiled so as to restrict the radiating surface** or render a part of the surface of the burner non-effective, and that this is an essential part of the invention. This paragraph corresponds to the **second claim, which must be limited to a coiled burner,** or one similarly arranged. Upon this assumption none of defendants' lamps embody the invention of the second claim. III., 1749-51, **6995-7004.**

The statement of discovery found in the patent in suit, in connection with a carbonized cotton thread, etc., is a mere statement of a fact predicated upon laboratory experiments without any thought that the resistance and stability and small radiating surface requisite for the use of lamps in large numbers in multiple arc could be secured otherwise than by coiling or similarly arranging the burner. There is nothing in the statement above referred to which can enlarge the scope of the invention beyond the limits established by the third paragraph. **This statement of invention limits the burner to a spiral** or similarly arranged form. III., 1752, **7005-8.**

That the resistance of electrical translating devices, when arranged in series, should be relatively low, and that it should be high when they are arranged in multiple arc, are general principles which were well known and of universal application at the date of the patent in suit. It was also known that the resistance of a wire or other conductor was most readily diminished by making it short and thick, and most readily increased by making it long and fine, and this principle was frequently employed in choosing

the dimensions of wires to be brought to incandescence by the electric current. That these principles were also well known in their application to incandescent lamps is shown by the abstract of **Wilson's paper,** published in "Nature," in June, 1878; also by **Lane-Fox's British Patents** Nos. 3988 and 4043 of 1878; and by **Edison's French and Italian Patents and his United States Patent No. 227,229.** [Note. *Wilson's paper and the patents referred to, deal with metallic or with composite burners only.*] III., 1755-7, **7019-25.**

At the date of the patent in suit **a person would have known how to proportion a burner** so as to obtain a resistance which would make the lamp suitable for working with other lamps according as they were to be arranged in series or multiple arc. He would have known that if the lamps were to be used in series, their resistance should be low, and that the burners should be made short and thick; and that if they were to be used in multiple arc, their resistance should be high and the burners should be made long and fine. III., 1757-8, **7026-9.**

Prior to the patent in suit, the known principles of electrical science would have led one, in constructing an incandescent lamp, to pay special regard to the distance from the source of current at which the lamp was to be used. For their economical operation, **it was known that the resistance of electrical devices should be high as compared with that of the rest of the circuit.** It would have been obvious that, as the distance of the device from the generator was increased, the resistance of said device should also be increased. This was a **familiar principal carried out in telegraphy,** in relays, sounders, galvanometers, etc. The **application of the principle to incandescent lamps would have been obvious.** If a person had had a lamp of low resistance, which was being used close to the generator, and had desired to remove the lamp to a distance, he would have known that the burner should be made of high resistance, and that this should be done by making it long and thin. The above statements are true, whether the person were considering a lamp which was to be used alone on a circuit, or whether such lamps were to be used in numbers. III., 1758-62, **7030-46.**

The Bernstein lamps, Thomson-Houston series lamps and Edison municipal lamps could not be used in multiple arc in large numbers with any system of distribution known at the date of the patent in suit. At that time, if a person had seen such lamps, and had been told to make similar lamps of the same candle-power, adapted for general use in multiple arc, **he would have known what changes should be made in the burners.** III., 1762-3, **7048-51.**

In June, 1879, **it would not have required invention to substitute a carbon burner in place of the platinum wire** in the

lamp structure described in Edison's platinum lamp patents. The change would have been the same as substituting one kind of metal for another. **Wild's paper on Lodyguine's lamp** refers to the superiority of carbon over platinum. III., 1764, **7053-5.**

In April, 1879, if he had been acquainted with **Edison's platinum lamp described in Patent No. 227,229,** and had been told to make a carbon lamp capable of the same extent of use, **he would have known what proportions to give to the carbon burner.** The recognition of **this would not have involved invention.** III., 1764-6, **7056-61.**

Agrees with Morton in regard to King's lamp. At any time prior to 1874, if he had been called upon to make a readily portable lamp under King's patent, he would have made the burner short and thick for series work. In making this burner he would be following out the directions of **King's patent,** which **sets forth the necessity of adapting the proportions of the burner to the condition of the circuit,** and also the precise manner in which the proportions would be naturally varied, that is, by varying both the length and cross-section so as to get a higher or lower resistance as might be desired. III., 1766-9, **7063-74.**

As to the vacuum which he would have used, that would have been the best which he could get with a **Sprengel or Geissler pump,** because **King indicates that the best procurable vacuum was to be used** by proposing to use a Torricellian vacuum. III., 1869, **7075.**

As to sealing the lamp chamber, he would have used platinum wires fused into the glass, because it was recognized that this was the only way to preserve a high vacuum in a chamber into and out of which an electric current was to pass. Moreover, **King's modified form of lamp (submarine lamp) instructs one to seal up the lower end of the vacuum chamber** above the mercury column, in the same way in which the upper end is sealed. This was a well-known procedure. **Masson, in 1852,** sealed off tubes by fusion after exhausting them by the Torricellian method. III., 1769-70, **7075-9.**

The mercury seal of King's lamp would last indefinitely. This opinion is substantiated by what is said in Patent No. 237,732 of February 13, 1881, where **Edison describes a lamp having a mercury seal.** III., 1770-1, **7080-1.**

Agrees with Morton in regard to the size of burner and the vacuum of Roberts's lamp. If he had been called upon to make lamps under Roberts's patent in 1878, **he would have proportioned the burners according to the character of the circuit,** and would have been led to make them of small section because of the instructions contained in the patent; for the same reason

he would have used the vacuum obtainable with a mercury pump. III., 1771-2, **7082-6.**

If, in 1878, he had been called upon to make **Sawyer-Man lamps** like those described in Patents Nos. 205,144 and 210,809 of 1878, and had found that they leaked, **he would—and without the exercise of invention—have prevented their leaking by fusing the parts together.** This was a familiar operation, pursued in the manufacture of **Geissler tubes and Crookes' radiometers.** In one form of the radiometer a current is passed through the walls of the chamber for the purpose of heating a platinum wire to incandescence. III., 1772-9, **7087-115.**

If, in 1878, he had been called upon to make **a lamp like that described in Farmer's Patent No. 213,643,** and had found it to leak, **he would have substituted a glass plug, with leading wires fused into it, in place of the elastic stopper, and would have fused the same to the glass globe.** He would have been following out Crookes' directions and would have been using the process employed by Edison in making the platinum lamp described in Patent 227,229. III., 1779-80, **7116-9.**

If, in 1878, he had made **a lamp like that described in Roberts' patent,** and had found it to leak, **he would have substituted a glass base for the metallic cap and would have fused it to the glass globe.** III., 1780, **7120.**

Edison did not make any "new departure" in the art. It was not new with Edison to use a burner of small cross-section and radiating surface, even though of considerable length. This principle had been recognized and used with platinum wire burners, for example, in **King's lamp** and in **Edison's platinum lamps.** The advantages of this constructed are pointed out in the British **Patents of Lane-Fox.** The **substitution of carbon for platinum would not involve invention,** and, moreover, the application of this principle to carbon burners was not new as **shown by patents of King, Roberts and Lane-Fox. Small burners made from Carre carbons had been used in incandescent lamps.** III., 1781-2, **7122-6.**

It was not new with Edison to employ burners made from a material which, upon carbonization, left a porous carbon residue. All carbon which results from simple carbonization is of this character. Moreover, various processes of producing porous carbon in the form of fine wires were known, for example, those of **Gaudin, Sidot and Carré.** The process described in the patent in suit is substantially the same as those of **Scott** and **Pulvermacher.** Evidence in this suit shows that **Sawyer and Man used such carbon** in 1878 and 1879. The use of carbon result-

ing from simple carbonization is attended with such difficulties that all lamp manufacturers, excepting the Edison Company, reduce the porosity by **hydro carbon treatment** even although it lowers the specific resistance very considerably. **Edison's testimony, given in the Canadian suit,** shows that the Edison Company has been able to omit this treatment only by the use of bamboo and by great refinements in the carbonization process. III., 1782-7, **7127-47.**

It was not new with Edison to reduce the material to shape prior to carbonization. Evidence in this suit shows that **Sawyer and Man did it.** The same is **true of Carré,** and the process was pursued by Carré, **Gaudoin** and **Pulvermacher** in making arc light carbons. These processes are **described in Fontaine's book. It was seldom that burners cut from gas-retort carbon were used.** III., 1788, **7150.**

The use of an all-glass globe, sealed at all points by fusion, was not a new departure with Edison in the patent in suit. **King's submarine lamp** and **Edison's platinum lamp** had this feature. The same is true of **Crooke's radiometers** and **Geissler tube lamps.** 1789, **7153.**

The advantages which result from small cross-section were true of the older carbon lamps. Does not think that their burners would have given out such an amount of heat as to injure the seal around the leading wires. III., 1789-90, **7154-60.**

There is nothing contained in the patent in suit to the effect that one advantage of the filamentary form lies in its **elasticity and flexibility.** Does not understand that flexibility is desirable, but, rather, **rigidity and strength.** Elasticity is a desirable feature, but a burner of excessively small cross-section is not necessarily any more elastic than one of larger size. III., 1791, **7162-3.**

The **advantages of small cross-section are present in the Bernstein and Thomson-Houston series lamps and in the Edison municipal lamps.** III., 1791, **7164.**

The invention of the patent in suit did not create a new art in lighting by electricity. The modern art is the result of many contributions by different inventors. Practical success followed from the impulse in the industrial application of electricity which commenced in 1877 and 1878. The success of the telephone was a stimulus. As to electric lighting, a great impulse was given to the art in 1878 by the successful lighting of some streets and public places in Paris with Jablochkoff candles, and by the sensational articles in regard to Edison's work. A great number of inventors turned their attention to the subject and the result has been a vast number of inventions relating to these and to allied arts. The growth of incandescent lighting has been

parallel to that of arc lighting, and the causes which led to commercial success have been the same in both cases. **The dynamo as originally constructed by Gramme was not adapted to incandescent lighting. It gave unsteady currents, was expensive and liable to get out of order, and was extremely inefficient.** By gradual changes the dynamo has been brought to its present perfection. The invention of the drum armature; proper proportioning of parts; a low internal resistance and high electro-motive force; improved methods of regulation, etc., were essential to the construction of a practical machine. Multifarious details had to be looked after. **Steam engines had to be improved,** also wire with improved insulation. **Systems of distribution had to be superadded to the multiple arc system to make central station lighting possible.** The introduction of **feeders** and of **interconnected mains,** and the **three-wire system,** together with meters, pressure regulators and indicators, have been of the greatest importance. The **transformer system,** added to the art in the past few years, has enormously extended the field of incandescent lighting. All the companies, excepting the Edison Company, use this system, and the latter company could not have made the progress which it has without the use of its three-wire system. A vast number of devices connected with an underground system, and others relating to the application of the light in houses, had to be devised. III., 1792-7, **7166-86.**

As to the lamp, a large number of inventions have contributed to its success besides that of the patent in suit, and some of them have been of vital importance. **Driving out occluded gases, described in Sawyer-Man Patent No. 210,-809, is essential** and is a process universally employed. **Hydro-carbon treatment, described in Sawyer-Man Patent No. 211,262, is very important** and is used by all manufacturers excepting the Edison Company. Other important inventions since that date of patent in suit are **Maxim's improved process of hydro-carbon treatment** and its application to standardizing the resistance of carbons; the **improved carbonization processes of Edison** and the introduction of **new materials and processes** and devices for shaping them; likewise improvements in the globe in methods of attaching the burner to the leading wires, and in mercurial air pumps, etc. III., 1797-8, **7187-90.**

That Prof. Barker has exaggerated the importance of Edison's invention is demonstrated by statement in **Edison Bulletin No. 21** which **refers to three of his patents as being fundamental.** III., 1798-9, **7191-3.**

Edison's testimony in the McKeesport suit is widely at variance with Prof. Barker's statements. (Note: *Here follows Edison's statement of the problem which he undertook to solve and what was necessary to accomplish it.*) III., 1799-802, **7194-207.**

Had Edison's invention been made in 1845 it would not have been a commercial success, because the other elements

necessary to its success were wanting. These elements were not available until long after that time. III., 1802-3, **7208-9.**

Defendants' M and Zigzag paper lamps are capable of wide use in general illumination with the transformer system which has come into use since the date of Edison's patent. III., 1803-4, **7210-3.**

Tamadine was invented after the date of the patent in suit, and is described in Weston's Patents Nos. 264,986 and 264,988 of 1882. III., 1804, **7214.**

No invention was required in going from a "rod" to a "filament." The adaptation of lamps to required conditions, by varying the length and cross-section of the burner, involved only the application of fundamental electrical principles. III., 1805, **7217.**

First became acquainted with **Geissler tubes** in 1867 or 1868, and **has had such tubes made for use as surgical and submarine lamps.** Refers to a description of such a lamp published in 1869. III., 1806-7, **7221-8.**

Has been acquainted with the **publications of the Royal Society concerning Crooke's radiometers** since their issue. These publications contain a description of a radiometer which embodies in its organization **an incandescent lamp.** It was **not intended by Crookes to be used for illuminating purposes,** but for the purposes, of subjecting certain objects to the influence of light. Describes several varieties of this radiometer, and says that they might have been used to light external objects within the range of their luminosity if one had so desired. Has one of these radiometers, which he has been in the habit of showing to his classes, on which occasions the platinum wire was heated to a bright red by the current. III., 1808-15, **7230-57**

Prof. Barker's quotation from **Schwendler's article, to the effect that subdivision must result in an engineering failure, relates solely to arc lighting** and not at all to incandescent lighting. The two operate on different principles, and the rules applicable to the one are not at all suited to the other. III., 1815-7, **7259-66.**

Schwendler recognizes that high resistance is necessary for multiple arc work. III., 1817-9, **7266-73.**

Prof. Barker's quotation from **Preece's article, to the effect that subdivision was hopeless and that experiment had proved it to be fallacious, relates only to arc lights.** Preece was somewhat behind the times. III., 1819-20, **7274-8.**

The kind of subdivision which Preece and Schwendler considered was a subdivision of light on the arc principle; that is, the production of many small arcs at the same economy as if the light was concentrated in one powerful focus. The **use of the term "subdivision"** in this sense became extended so as to cover the different principle of **multiplying lights** supplied from the same source without attempting to secure the same amount of illumination with the same expenditure of energy. **Edison used the term in the latter sense** in his earlier patents and publications relating thereto. III., 1820-3, **7279-90.**

Experience justifies the conclusions of Preece and Schwendler. If a number of lights, either arc or incandescent, are operated at different points, this procedure is very uneconomical when compared with the luminous effect which is produced by the same amount of energy expended in one light at a single point. III., 1823-4, **7292-3.**

Prof. Barker quotes from Schwendler, as published in the "Telegraphic Journal" for 1879, to show that the principle of high resistance, as a condition necessary to the extensive subdivision of the incandescent light, was not recognized. Prof. Barker omitted an important part of the paragraph which modifies the meaning of the whole. **Schwendler thought that incandescent lighting must be much cheaper than gas before it could come into general use.** It was true then, and is to-day, that **incandescent lighting generally is not cheaper than gas,** and in most cases it is decidedly dearer. There is nothing which Schwendler says to justify Prof. Barker's conclusions. [Note: *That part of Cross's answer contained on pp. 1826-7, folios 7301-6, as to what he thinks Schwendler took into consideration, is not supported by what Schwendler says.*] III., 1824-7, **7295-307.**

The **Geissler pump** was brought out about 1868, and the **Sprengel pump** in 1865. III., 1827, **7308.**

The arch form of burner is particularly important with carbon, as this form permits it to adapt itself to the stresses produced by changes of temperature. It is exceedingly liable to rupture if in the form of a straight strip (McKeesport suit). III., 1846-7, **7384-8.**

The advantages of the arch form are obtained in the burner shown in Sawyer-Man Patent No. 317,676, and are not present in the burner of **Roberts' lamp** (McKeesport suit). III., 1848-9, **7389-93.**

In modern lamps, the **advantages arising from the capacity of the burner to expand and contract without breaking**

would not be present whatever the form of the conductor (McKeesport suit). III., 1849-50, **7295-7.**

The burners of all lamps made since 1880 are arch-shaped (McKeesport suit). III., 1850-1, **7400-1.**

A V-shaped burner is not equivalent to the arch form. Sawyer and Man have used the V form (McKeesport suit). III., 1851, **7402.**

The arch form is new with Sawyer and Man as applied to carbon burners (McKeesport suit). III., 1851-3, **7404-9.**

The primary advantage of the arch form is not for the purpose of getting a great length of burner in a limited space. This form is used in some cases where there is room enough for the conductor if straightened out (McKeesport suit). III., 1853-4, **7410-3.**

Sets out the advantages of fibrous carbon with respect to its purity, evenness of texture, high specific resistance, firmness, elasticity and toughness; also with respect to its susceptibility to the tempering and hydro-carbon processes, and finally to the facility with which it can be shaped before carbonization (McKeesport suit). III., 1857-8, **7425-30.**.

It is not true that, while high specific resistance is desirable for lamps of high total resistance intended for use in multiple arc, it is of no advantage for lamps of low total resistance intended for series work. **High specific resistance is desirable in both high and low resistance lamps** (McKeesport suit). III., 1858-9, **7431-5.**

The patents of Staite, Kosloff and Roberts do not show a base which is the equivalent of the Sawyer-Man glass base or stopper (McKeesport suit). III., 1863-4, **7450-5.**

The Sawyer-Man lamp would not be useless. The lamp structure and fibrous carbon burner would have great advantages. The lamp shown in the drawings of the patent **would be of low resistance,** and would require a low electro-motive force and a strong current, but it would be just the right lamp for series work. The lamp chamber, as a protection against leakage, is imperfect, and no doubt some other form would be preferable for general use on a large scale, but it is fitted for practical commercial use just as it stands. The lamp **would not compete with gas nor with modern lamps,** but, with nothing better in existence, it would have a commercial value for many purposes. Thinks such a lamp **could be made to last fifty to one hundred hours.** Does not agree with the experts of the Edison Company that the Sawyer-Man lamp chamber has all the defects of those

of prior lamps, but believes that **the glass base will materially diminish liability to leakage** and prolong the life of the lamps (McKeesport suit). III., 1865-7, **7459-68.**

Sawyer and Man made a substantial advance in the art by their invention described in Patent No. 317,676. **Their improvements** were a fibrous or textile carbon burner, and such a burner in the arch form. These have made modern incandescent lighting possible (McKeesport suit). III., 1868, **7469-72.**

The novel and useful elements contained in the first, second and fourth claims of Sawyer Man patent are: the fibrous carbon burner in the arch shape, mentioned in first claim; the carbonized fibrous material of the second claim, and the lamp chamber of the fourth claim (McKeesport suit). III., 1869-71, **7474-83.**

The Sawyer-Man patent sufficiently describes the character of the fibrous material to be used for the burner; also its selection, preparation and carbonization, to enable a skilled person to make a practicable burner. The mention of paper and wood would lead one to select a pure paper of uniform structure and even texture, or a wood with long and parallel fibers. **He would probably have picked out a cotton thread.** He would have given it the desired shape before carbonizing it. **As to carbonization, the patent describes no special process.** This was unnecessary in view of the state of that art (McKeesport suit). III., 1872-5, **7486-98.**

Prior to 1880, a person would have known that a burner made from a strip which had been cut across the fiber in any part of its length, would be useless. No one would, upon being instructed to use carbonized fibrous or textile material, have attempted to make a burner in this way. **He would naturally have selected material in which the fibers are continuous and which would not be cut or broken in shaping.** If he desired to give the burner the arch form, he would have bent the material into that shape before carbonizing it. He would not have selected wood having interlacing fibers or one that is resinous. There would be less difficulty in selecting a proper material out of which to make thick burners, like those shown in the drawings in the Sawyer-Man patent, than in finding a material suitable for hair-like filaments. **The process of electrical heating and the hydro-carbon treatment increase the number of fibrous and textile materials which can be used in making burners.** These peculiarities of **bamboo,** which make it particularly suitable as a material out of which to make very slender filaments, were understood prior to 1880 (McKeesport suit). III., 1875-80, **7499-518.**

Discussion of **what constitutes an arch shape** within the meaning of the Sawyer-Man patent (McKeesport suit). III., 1890-3, **7559-70.**

Has no experimental knowledge with regard to use of deposited carbon or gas carbon, or that made by Gauduin's process (McKeesport suit). III., 1896-7, **7583-8.**

Thinks that the **hydro-carbon process** and that of **Gauduin** ought to give quite different results (McKeesport suit). III., 1898, **7589-92.**

Gauduin's process, and the hydro-carbon treatment described in Sawyer-Man Patent No. 211,262, both result in a deposited carbon obtained by the decomposition of a hydrocarbon by heat, but it does not follow that the properties of the deposited carbon will be identical in both cases. It would neither be fibrous nor textile carbon although it might be a vegetable carbon (McKeesport suit). III., 1898-1900, **7589-97.**

Thinks that the **carbon deposited by Gauduin's process would have a different specific resistance from that deposited by Sawyer-Man hydro-carbon process.** The patents of both inventors mention the use of hydro-carbons proper, and also of those which contain oxygen (McKeesport suit). III., 1901-3, **7602-9.**

An incandescent lamp, having a life of one hour, might have a distinct commercial value if there were no better lamp. There would be but little demand for such a lamp and it could not compete with other illuminants (McKeesport suit). III., 1905, **7619.**

The arch shape would have advantages with a burner made of any kind of carbon, but it might not be the means of preventing the rupture of a burner of this shape made from brittle carbon like gas carbon. Is, however, undecided on this point (McKeesport suit). III., 1906-7, **7621-5.**

Admits that he **was retained by the Edison Company about 1881,** and that he made examinations of patents and publications, and wrote to Mr. Betts, counsel for said company, concerning them (McKeesport suit). III., 1911-2, **7642-6.**

Identifies two **letters written to Mr. Betts** in 1881. III., 1913, **7652.**

Says that the **literature relating to subdivision** prior to date of patent in suit is not extensive. III., 1916, **7664.**

Testifies as to **correspondence with Mr. Betts, Mr. Wilbur and Mr. Eaton.** Says that he believes that all the correspondence and papers, relating to his report to the Edison Company, have been produced. [**Note.** *Other letters were afterwards found and put in evidence. See Vol. V., p. [illegible].*] III., 1917-9, **7668-75.**

Does not feel sure from Preece's article that the author considered multiplication of lights and subdivision of the light to be one and the same problem. **Preece's demonstrations proved nothing as to multiplying lights.** III., 1920-1, **7680-4.**

Concerning his lecture entitled "The Criteria of the Electric Light," it shows that **Preece did not have the grasp of the subject** that he would have had if he had been dealing with a problem in telegraphy, regarding which his opinion is of especial value. III., 1921, **7683.**

Sees nothing in the various articles from the **literature relating to subdivision,** which are at this point offered in evidence, to change or modify his opinions. III., 1919-30, **7676-718.**

The invention involved in the McKeesport suit was a lamp with a chamber made wholly of glass and with a **fibrous or textile carbon** burner in the arch form. **The patent now in suit** does not relate to a burner made of this material, since it specifically describes one made from **tar putty.** III., 1930, **7720.**

In regard to his **correspondence with Mr. Betts in 1881,** he received a copy of the patent in suit; of Edison's platinum patent; memoranda by Mr. Wilbur, and samples of the Edison and Maxim lamps. He examined these and a number of English patents to which his attention had been called. Mr. Betts wished him to consider whether the **Maxim lamp was of high resistance,** and whether the leading wires were of platinum and sealed into the glass as set forth in one claim of Edison's platinum lamp patent. **A criterion by which to judge the question of high resistance was suggested by Mr. Betts.** His report was a general and hurried one, and he assumed that it would be followed by personal conferences, and he, therefore, put the report largely in the interrogative and conditional form. **He did not at the time form an opinion as to whether the "high resistance" of the first claim of patent in suit, was a high total or high specific resistance.** He now believes with Prof. Barker that it refers to high specific resistance. In his letter of June 23, 1881, to Mr. Betts, in which he says that Edison, for the first time, describes a process by which a carbon filament can be made practially, he did not make any full investigations of the subject, and worded his report so as to indicate that his conclusion was not a final one, but was based upon general impressions. Since that time he has be-

come acquainted with old processes for making such burners, like the processes of **Scott, Sidot** and **Gaudoin.** Has also learned that **Carre had made carbons for incandescent lighting, having a diameter of only a millimeter or even half a millimeter.** At the time of writing to Mr. Betts, he made no calculation as to how high the total resistance of a lamp should be to enable it to be used in **large numbers in multiple arc.** Taking **Mr. Betts' test of high resistance,** *i. e.*, whether a given lamp can be worked in large numbers in multiple arc, without employing main conductors of large dimensions, **the Maxim lamp would not be a lamp of high resistance.** Such a lamp could not be employed in multiple arc in large numbers in competition with gas, and would require conductors of such large size as to make such competition impossible. In considering the questions submitted by Mr. Betts, he did not take the earlier lamps having metallic burners into account, or the English patents, and "London Times" article of Lane-Fox. III., 1931-5, **7722-37.**

Taking the **Lane-Fox article in the "London Times"** as a basis for calculation, lamps of 100 ohms resistance would require **main conductors of copper having a diameter of three inches.** III., 1935-6, **7738-41.**

A full consideration of the publications upon subdivision, put in evidence by complainant, does not change his views, but many of them sustain his assumption that in certain of its features **the Edison lamp is the result of fundamental and well recognized principles of electrical engineering.** It is true that, when the general introduction of incandescent lighting as a competitor with gas was first considered, the idea was looked upon as visionary, and justly so, for **to-day it cannot compete with gas** in price, even with the aid of all the improvements which have been made. Incandescent lighting has manifest advantages, on account of which a small portion of the public is willing to pay more for it than for gas. **The number of incandescent lamps in use in the United States is five per cent. of the number of gas jets. Competent authorities did not question the possibility of multiplying lights,** that is, of producing many lights from one machine; but they simply considered either that it would not pay, or that difficulty would be found in producing electricity in sufficiently large quantities by means of dynamos; in their regulation; in the durability of the burner, and in the danger to life and property. **The doubts entertained did not relate simply to the lamp but to the whole engineering problem.** All of the difficulties presented, including the distribution of electricity, were matters of engineering, **the theoretical essentials of which were calculable from existing data.** The question always was whether the theoretical necessities could be fulfilled, and whether, if fulfilled, the enterprise could be made to pay. There was a universal and just **skepticism in regard to**

the absurd statements of Edison's projects, made on various grounds, which purported to express his views. The article in the "New York Sun," republished in the "Telegraphic Journal" for Oct. 15, 1878, is one example of such statements. III., 1936 8, **7444-50.**

This skepticism was not removed when his invention of an impossible dynamo, and a lamp having a metallic burner, became known. This lamp figured in the **"Engineer" article** of Feb. 14, 1879, and the conclusions expressed therein are true. The same device was referred to by **Sylvanus Thompson** in his **letter to "Engineering"** of October 25, 1878, and in his **lecture published in "Engineering"** of December 20 27, of 1878, and by the witnesses before the **Parliamentary Committee.** The reports of their testimony show that, while they recognize the engineering difficulties in the way, they almost universally agreed that **multiplication of lights was possible. This is shown by the testimony of Cooke, Siemens, Preece, Tyndall, Hopkinson and Sir William Thomson.** The testimony of the experienced electrical engineers Thomson, Siemens and Hopkinson, is to the effect that subdivision was practicable, though likely to be costly. In this last idea they were correct, although improvements in dynamos, systems of distribution, lamps, and other electrical devices and in the efficiency of steam engines, have doubtless reduced the cost below their expectations. III., 1938 48, **7751 90.**

Chapter XI. of Fontaine's work does not indicate that multiplication of lights with proportionate increase of power was impossible, although it might be inferred that he questioned whether this would pay commercially. **Chapter XII. does not show that subdivision was impossible,** but that De Changy's (platinum) lamp had accomplished it as stated by Jobart. III., 1948-51, **7791-801.**

Chapter X. of Higg's book does not intimate that subdivision is impossible, but describes the best methods of accomplishing it. III., 1951, **7802.**

The **editorial in the "Telegraphic Journal"** of October 15, 1878, is jocular in tone, but instead of thinking that **multiplication of lights** is impossible, the author says that **any day may see its accomplishment.** III., 1951, **7804.**

Trant's letter in "Nature," so far as it relates to Edison's lamps, refers only to the platinum lamp. His data is taken from Fontaine. He considers that **subdivision is too wasteful** to allow the use of incandescent light for general purposes, and says that **subdivision was discovered long ago.** Trant was unknown as an authority whose opinion should be be given weight. III., 1952, **7805.**

As to the **editorial in "Engineering,"** for January 10, 1879, it presents no evidence of having been written by a person competent to deal with the subject, but the author's conclusion is simply that it will not pay, and that to light all London from a few stations would require too great a cost for conductors. Whether his calculations are correct or not, **it would not be practicable with 100 ohms lamps in simple multiple arc to light London to-day.** The author's

statement that, with lights suitable for house illumination, there will be an enormous reduction of light furnished by a given current as compared with the light which would be produced in a single focus—as in one arc light—is true to-day. III., 1952. **7807-9.**

The editorial in "Engineering" for February 14, 1879, describes **Edison's tuning-fork dynamo and an early platinum lamp.** The author does not consider that this system solved the problem of commercial lighting, nor that the lamp would accomplish subdivision on a great scale. III., 1953. **7810.**

In his lecture on the criteria of the electric light **Preece recognizes that multiplication is different from subdivision.** In speaking of subdivision as being an *ignis fatuus*, he refers to the production of a large number of lights with the same economy that can be obtained with a single larger light. He says nothing explicitly against the possibility of multiplication of lights. III., 1953-4. **7811-3.**

The **editorial in "Nature"** discusses the Edison carbon lamp as described in the "Herald" article. Nothing is said to justify the conclusion that the author considers the use of incandescent lighting for general illuminating purposes an impossibility. The author does not believe that the lamps can be made for the low price stated in the **"Herald" article,** or that Edison's dynamo has the high efficiency therein ascribed to it, or the statement as to the exceeding cheapness of the light which is contained in the "Times" article. The experience of the past ten years has justified his belief. The author also considers that **Edison's lamp is not new,** but that **it is substantially the same as those of King and Lodyguine.** He refers to the use of **high resistance** as **an obvious deduction from Joule's law.** III., 1954. **7814-5.**

The articles of Du Moncel in "La Lumiere Electrique" do not convey the impression that there is any **invention in the use of a high total resistance,** or that the **problem of multiplication of lights was** other than **an engineering one.** The first article states that a study of the problem must lead to more satisfactory results; that the law of the square explains why there is so much **loss in thus dividing the light,** and that much research is necessary to make the electric light a success; but the belief is also expressed that there will be developments which will cause a partial transformation of public lighting. The second article considers that **the Edison lamp is similar to those of King and Lodyguine,** and that, while it may prove to be a better lamp, it is not the important invention which American journals would lead one to suppose. The third article, published October 1, 1881, describes the complete Edison system, and says that **it is the totality of Edison's inventions that commands attention.** It is not intimated that the author considers the high resistance of the lamp as a novel, noteworthy and epoch-making invention, or that it solved subdivision. **No one alludes to high resistance as a novel feature of Edison's invention,** neither has this principle been recognized as other than a feature of adapting a lamp to the circuit, which is a matter of engineering skill. III., 1954-6. **7816-22.**

Farmer, in "Silliman's Journal," and Lane-Fox, in the "London Times," recognized the possibility of multiplying lights. That **the scientific world did not consider the lamp alone as being necessary to solve the problem,** or that Edison's lamp, described in the patent in suit, gave anything approaching its complete solution, is apparent from the fact that the discussions in various **publications which followed the "Herald" article relate to the paper-carbon lamp** therein described. This paper-carbon lamp was much better than the (tar-putty) lamp described in the patent, and yet there was the greatest skepticism as to its value as a rival to gas. This is shown in the **second article of Du Moncel;** in **Outerbridge's lecture,** and in an **article on Edison's Horse-shoe lamp, published in "Engineering"** for May 14, 1880. III., 1956-9. **7823-36.**

As to the **extract from the third edition of Fontaine's work** on electric lighting, published in 1888, there is nothing which relates to the invention covered by the patent in suit. The author refers to a bamboo lamp which was devised at a later date, and which differs from the (tar-putty) lamp of the patent. **The author's high estimation of Edison is not based on his lamp,** but upon the various inventions relating to electric lighting which Fontaine attributes to him. III., 1959-61. **7836-41.**

EDISON, T. A.:

After stating that **the use of a mandril, upon which to coil a spiral, would be self-evident,** witness denies any knowledge of having filed an application for a patent for doing this. Identifies a caveat filed by him on December 22, 1879. IV., 2554-5, **10216-8.**

The Geissler tube is an incandescent lamp. III., 1243, **4972.**

Geissler tube construction explained. III., 1244-5, **4973-7.**

Sometimes, **Geissler tubes have a capillary bore** smaller than some filaments. III., 1246, **4981.**

Geissler tubes have been made and sold to be used as lamps. III., 1246, **4982.**

Geissler tubes have a vastly greater resistance than carbon filaments on account of the extremely **high specific resistance** of the gaseous medium. III., 1247, **4986.**

The term "burner" is as **applicable to the thread of gas of a Geissler tube** as to the burner of a platinum or carbon lamp. III., 1248, **4991.**

The leading-in wires of Geissler tubes, where they pass through the glass, are of platinum, which is used because it is the only material which can be fused to glass and make a tight joint. This advantage in platinum has been known for at least fifty years. III., 1250, **4997-9.**

Geissler tubes have an all-glass chamber, with joints closed by fusion. III., 1251, **5004.**

The vacuum in Geissler tubes varies from the highest obtainable to less than that ordinarily secured in common incandescent lamps. III., 1252, **5006.**

The cross-section of the bore of Geissler tubes is made small to increase their illuminating power. III., 1252, **5007.**

The vacuum obtained by following the instructions of King's patent would be extremely efficient. III., 1253, **5011.**

An efficient vacuum could be obtained in King's lamp with the Geissler or Sprengel pump. The lamp would be **sealed off** from the mercury column by fusion of glass. III., 1254, **5013.**

No invention involved in using Geissler or Sprengel pump to exhaust **King's lamp.** III., 1254, **5015.**

King's patent instructed the art to seal off the lamp from mercury column by fusion when it was to be used for **submarine lighting.** III., 1255, **5018.**

MORTON, Dr. Henry:

King's submarine lamp would have both leading wires of platinum, and they would be fused into the glass chamber. III., 1255, **5020.**

King's patent instructed the art to make the burners as thin as possible in order to obtain small mass, high resistance, and small cross-section. The attending advantages would have been apparent to a skilled person. III., 1256-7, **5022-7.**

A skilled person would make King's burner for multiple arc work longer and thinner than for series work, but in both cases, as thin as the character of the circuit would permit. III., 1259, **5033.**

How Morton would have made a King lamp in 1878. III., 1259-60, **5035-9.**

The relation of the resistance of a lamp to the character of the circuit was known prior to 1878. III., 1260, **5040.**

The resistance of multiple arc lamps is usually one hundred ohms or higher, and of **series lamps** from less than one to eight ohms. III., 1261, **5041.**

There is no **difference between multiple arc and series lamps,** excepting in thickness and length of burner and size of leading-in wires needed. III., 1261, **5044.**

Prior to 1878, the **sealing of platinum conducting wires** into the glass walls of **Geissler tubes** and of **Crookes's radiometers,** and the **exhausting and sealing** them off from the air pump by fusion of the glass connecting tube, was customary. III., 1262, **5045.**

Prior to 1879, it was a well-understood principle that the burner of an incandescent lamp should have as **small cross-section** as was practically obtainable. This is gathered from **Roberts's patent** and **Lane-Fox's patent** No. 3988 of 1878. III., 1262-3, **5048-9.**

Roberts's patent virtually states that as perfect a **vacuum** as was then obtainable should be used. III., 1264, **5053.**

In 1878, he **would have used a Sprengel or Geissler pump to exhaust Roberts's lamp,** and would have obtained the highest possible vacuum in order to remove all matter capable of acting on the carbon. III., 1264, **5055.**

In 1878, he **would have substituted an all-glass chamber** similar to that of a **Geissler tube** for the separable chamber in **Roberts's lamp.** III., 1264, **5056.**

Tables of specific resistance of carbon and of the carbon of defendant's filaments. III., 1265-8, **5059-70.**

The relatively **low specific resistance of the carbon of defendant's filaments** is due to the **hydro carbon treatment,** which makes the carbon dense and homogeneous. III., 1269, **5074.**

Morton's 44 Q. and answer in the McKeesport suit do not correctly state the substance of **what Edison said in regard to the use of a high specific resistance** in lamps of high total, and of low total resistance. See III., 1275, **5098;** also, 1335, **5339.**

It was old to use a filament, not of carbon (meaning a platinum wire), enclosed in a highly exhausted all-glass globe, with platinum leading wires fused into the glass walls of the globe (Canadian suit). III., 1280, **5119.**

With reference to **Sawyer-Man Patent No. 317,676,** the prominent features contained therein, to the effect that the incandescent conductor is to be made of carbonized fibrous vegetable or textile material in the form of an arch or loop, **instruct a person to select suitable cotton or linen thread** of uniform cross-section, or strips of grass or reeds, and especially **bamboo.** He would naturally cut the material parallel with its fibers and bend it into an arch before carbonizing it. Instructed to use paper, he **would select a paper made wholly of vegetable fiber of uniform thickness** and would first shape it. If familiar with the art in 1880, he would have used the **hydro-carbon treatment** if found desirable. No special instructions would be required as to the method of **carbonization** to be followed (McKeesport suit). III., 1289-92, **5156-67.**

Instructed to use a fibrous vegetable or textile material, a person would have selected one of uniform structure, and had he applied the **hydro-carbon treatment** after carbonization, **he would have made an operative burner** (McKeesport suit). III., 1297, **5185.**

Modern practice demonstrates that **a very fine fiber is not universally necessary or desirable,** as shown by the **Edison municipal lamp** and by the **Thomson-Houston, Heissler and Bernstein series lamps** (McKeesport suit). III., 1303-4, **5212, 5115.**

The **Sawyer-Man patent** immediately **suggests the use of a carbonized thread** or string (McKeesport suit). III., 1304, **5216.**

Roberts's patent, although mentioning "charcoal," **instructs the art to use graphite,** gas-carbon and the like (McKeesport suit). III., 1311-2, **5240-7.**

The carbons described in Greener & Staite's Patent, No. 11,076, of 1846, are intended for use only in **arc and semi-incandescent lamps,** and are not made from fibrous material (McKeesport suit). III., 1314-5, **5254-9.**

From the **"Golos" article upon Lodyguine's lamp,** which was published in the "London Journal of the Society of Arts" in 1873, it appears that the use of the word "charcoal" therein has no reference to wood carbon, but that **hard arc light carbon was used** (McKeesport suit). III., 1315-7, **5260-6.**

Konn's Patent No. 3809, of 1872, suggests the use of graphite only and has no enclosing vessel adequate to the vessel of the **Sawyer-Man patent,** which is **wholly of glass** (McKeesport suit). III., 1317-9, **5267-73.**

De Moleyn's lamp, of 1841, is inoperative and bears no relation to a lamp having an arch-shaped burner made from fibrous material or to a chamber made wholly of glass (McKeesport suit). III., 1319, **5274.**

Binks's Patent No. 119, of 1853, refers only to a process of making arc light carbons. This fact should dispose of it as having no relation to the making of incandescent burners. Carbonized lignite is suggested. This material has preserved in it none of the fibrous structure of the original matter from which it was derived (McKeesport suit). III., 1319-21, **5276-83.**

Carbon has **advantages, when in the arch form,** which are not possessed by other materials (McKeesport suit). III., 1331-3, **5321-9.**

The **arch form of burner was new with Sawyer and Man. Konn's V-burner** is not an arch (McKeesport suit). III., 1334, **5336.**

The **Sawyer-Man lamp chamber has not the defects existing in those of prior lamps,** because it is wholly of glass. It would have utility, and the lamp, as a whole, would have a certain amount of **commercial usefulness,** although it might not compete with modern lamps. The **burner would undoubtedly last from 100 to 200 hours** (McKeesport suit.) III., 1337-9, **5348-55.**

Sawyer and Man made a substantial advance in the art in respect to an arch shaped burner made from fibrous or textile materials

and enclosed in an air-tight chamber constructed wholly of glass (McKeesport suit). III., 1339, **5356.**

Sawyer and Man made an invention in making a burner of any shape (certainly in the arch form) from carbonized fibrous or textile material, and in enclosing this burner in an hermetically sealed lamp chamber made wholly of glass (separable glass base), from which all carbon consuming gases had been expelled, and in having leading-in wires which pass through and are hermetically sealed (cemented) into the glass, as described and claimed by them (McKeesport suit). III., 1340, **5358-60.**

The arch form has advantages for carbon made from fibrous or textile material, which are of no value for metal or hard carbon (McKeesport suit). III., 1341, **5362.**

A burner of **hard carbon, being brittle, would be likely to break from strains** produced by expansion and contraction, whether in the arch-form or straight, although the arch-form would overcome this difficulty to some extent (McKeesport suit). III., 1343-4, **5371-6.**

The **reason why the King, Roberts, Konn and other lamps, prior to 1879, did not come into commercial use** were: cost in generating electricity; imperfection in methods of creating and preserving a vacuum; in making carbon burners, and in distributing and regulating electric currents. III., 1347-9, **5388-95.**

Carré, Gauduin and Sidot made important contributions to the art of making carbon conductors, resulting in the production of such conductors of **uniform structure** and **small cross-section. Sawyer and Man** added the more important **hydro-carbon treatment** and introduced carbon conductors made from vegetable, fibrous or textile material. III., 1349, **5394.**

Everything which was known prior to the date of the **"Herald" article** of December 21st, 1879, concerning the art of **distributing electricity,** would have been inadequate to achieve **commercial incandescent lighting.** [Note: *See what Morton says in regard to the* **commercial value of the Sawyer-Man lamp** *on pages 1358-9.*] III., 1349, **5395.**

Prior to 1879 little or **nothing had been done as to the methods of distributing electricity** which are essential to the commercial success of electric lighting, although the general principles involved in these methods were well known. III., 1350, **5398.**

The standard of efficiency for lamps which was in general

contemplated by him in his articles in the "American Gas Light Journal;" in the "Sanitary Engineer," and in an interview published in the "New York Times," was such as would lead to the all but immediate supplanting of gas by the electric light, and would involve supplying electric light at a price many times less than gas light, and the manufacture of electric lamps at a cost that would approach that of ordinary gas burners. III., 1352, **5406** *et seq.*

His statement in the **"Times" article,** to the effect that, up to the publication of **"Herald" article, all attempts to make a practical lamp had been failures,** and that **Edison's lamp** described therein did not seem to contain any novelty promising better success, is as true to-day as it was when the "Times" article was written. III., 1358, **5432.**

Edison's paper-carbon lamp never attained any commercial use or success. III., 1359, **5435.**

Quotes **Edison's testimony in the McKeesport suit** concerning disadvantage of using **paper carbons.** III., 1359-60, **5435-40.**

Improvements have been made since the date of the "Herald" article, such as selection of **bamboo,** the better methods of **carbonization** and improvements in **hydro-carbon treatment,** which have made lamps more reliable, but they **do not compete with gas.** III., 1361, **5442-4.**

In the **"Times" article,** in criticising Edison's lamp which was described in the **"Herald" article,** he thought they would cost from $1.25 to $1.50 each. **Improvements made since 1879 have reduced the cost of lamps to about twenty-five cents,** which was the cost price given in the "Herald" article. III., 1361-2, **5444-6.**

Arc lamps give about ten times the amount of light which incandescent lamps produce with the same expenditure of power. Incandescent lamps give about the same amount of light as gas with the same coal consumption, but **gas has the advantage** of cheaper labor and plant, facility of storage, and a market value for residual products. III., 1362, **5447.**

Edison's paper carbon lamp, described in the "Herald" article, would not stand mechanical shocks as was demonstrated in the case of the **plant in the steamship "Columbia."** III., 1364, **5454.**

To-day **incandescent lighting does not compete with gas** excepting in the case of **isolated plants,** and then only under favorable conditions. III., 1364, **5456.**

Incandescent lighting has not displaced gas lighting. **Twenty gas burners are installed to one incandescent lamp.** III., 1365, **5457.**

The improvement in the hydro-carbon treatment made since 1880 would be essential to make the **paper carbon of Edison's lamp,** described in the "Herald" article, durable. The process known prior to that time (**treatment in a hydro-carbon liquid**) is applicable in the manufacture of single low resistance lamps, but not in making of those of **high resisistance** for use in multiple arc. III., 1366, **5461.**

Attempts to explain **his position with respect to the impossibility of subdivision** as given in his **"Tribune" interview** and in his **"Gas Light Journal" article.** III., 1370-1, **5479-84.**

Admits having been **elected an honorary member of American Gas Light Association** after his lecture on the electric light, which was delivered before that association. III., 1373, **5491.**

Lane-Fox's Patent No. 3988, of 1878, describes a multiple arc arrangement of circuits and sets forth that, in carrying out this arrangement, **the resistance of the platinum burner should be high as compared with that of the conducting wires, and it should be of small cross-section,** so as to concentrate the energy in such a way as to secure its economical operation. III., 2050e, **8197e.**

In both the patent in suit and in Lane-Fox's provisional specification No. 1122, of 1879, methods are described for making burners of high resistance. In both cases **the burners are of carbon, and are to be of small cross-section,** so as to concentrate the action and obtain a high temperature. The burners are also to be connected to **platinum leading-in wires,** hermetically sealed into an **all-glass vessel,** which is also hermetically sealed, and from which air, moisture, and deleterious substances are removed. [Note: *This is not exactly correct. Lane-Fox says: "From this globe, all trace of oxygen, carbonic acid gas, water and any gas or vapor capable of attacking or affecting the material of the luminous bridge when at a high temperature must be removed." This does not mean, as Morton says, that "air" is to be removed in the sense of obtaining a vacuum.*] As to the differences between the patents, **Lane-Fox secures a high resistance by mixing a low conducting material with the carbon** as well as by the small size of his burner, while **Edison obtains a high resistance by the length and thinness of the burner and its porous character.** There is no other difference excepting that Lane-Fox

MORTON, Dr. Henry.

suggests that his burner may be coated with carbon by the **hydro-carbon process.** III., 2050*e*-2050*f*, **8198e-8198f.**

Lane-Fox's provisional specification No. 1122, of 1879, describes a burner of higher specific resistance than that of Edison. The expression "the conducting wires are hermetically carried" through one portion of the glass globe, refers to **sealing** by fusion of the glass. The **patent describes a carbon burner** because it mentions the same as being made from "two refractory materials, one of which is a conducting material, such, for example, as plumbago." The expression, "such, for example, as plumbago," is equivalent to the expression one or other forms of carbon. **This Lane-Fox lamp would be a better lamp and one easier to construct than the lamp described in Edison's patent.** III., 2050*f*-2050*g*, **8199f-8199g.**

SHALLENBERGER, Oliver B.

Tables giving data concerning **experimental lamps made by Shallenberger and tested for the purposes of this suit.** The burners of these lamps are made of carbonized silk thread and have been subjected to **hydro-carbon treatment.** They are contained in all-glass globes with platinum leading wires fused into the glass. **Some have been run sixty or seventy hours.** All of them have been tested on the pumps for three or four hours while at a much higher incandescence than would be practically used. Has no doubt of their reasonable durability. III., 1378 80, **5509 17.**

Carbon burners would not be suitable for use unless subjected to additional treatment after simple carbonization in the furnace. **Occluded gases must be driven off and the carbon consolidated by electrically heating the burner while chamber is being exhausted.** Without this process, carbon is deposited on the glass and the lamp soon deteriorates to such a degree as to render it useless. III., 1381, **5521-2.**

The flexibility of the material out of which burners are made is greatly reduced by its carbonization. The burners must be handled with great care to prevent their rupture before they are mounted ready to be placed in the lamp chamber. III., 1381, **5524.**

The fact that the material is reduced to **shape prior to its carbonization has no effect on the specific resistance** of the resulting carbon. III., 1382, **5525.**

Carbons from four to eighty thousandths of an inch in diameter can be readily attached to the leading-in wires. By properly regulating the process, however, the size of the carbon is almost a matter of indifference. III., 1382, **5527.**

Edison lamps, ranging from 93 to 112 volts and from 10 to 100 candle-power, are adapted for use in multiple arc in considerable numbers over limited areas without the aid of methods of distribution and regulation introduced since 1880. Appliances contrived since that time have made **central station lighting, broadly considered,** possible. Central station lighting means the distribution of current from a source under such conditions as render it possible to supply electric lights of the power of a gas jet over areas sufficient to furnish electric lamps as the demand may require, and in the same way as gas is distributed for lighting residences and stores. III., 1385, **5540.**

Lamps of less than 100 ohms resistance could not have been used for central station lighting in 1880, because **no method of distribution was then known** which would not have been too expensive. III., 1386, **5541.**

Defendant's M lamp of 40 ohms hot resistance, and the Zigzag lamp of 80 ohms, could not be used for central station lighting to-day without making use of methods of distribution devised since 1880. III., 1386, **5542-3.**

Has made a successful carbon burner as small as three thousandths of an inch in diameter. [Note. *The burner referred to was experimental and was made for the purposes of this suit. It was a carbonized silk thread subjected to hydro-carbon treatment. See 1379,* **5513.**] III., 1386, **5544.**

Has had no difficulty in sealing in platinum leading-in wires as large as .080 of an inch in diameter which would maintain an **effective seal with even 35 amperes of current.** In some cases this current was sufficient to heat the wire to redness down to the seal and without injurious results. III., 1387-8, **5546-9.**

Has used burners as large as .055 to .060 of an inch in diameter. [Note. *The burners referred to were experimental and made for the purposes of this suit. See 1378-9.*] III., 1388, **5549.**

From his acquaintance with the laws governing the distribution of electrical energy in circuits, **a person would have known in 1878 that carbon burners should be of high resistance if used in multiple arc** and would have been able to determine the changes which should be made in the dimensions of a **series burner,** as to cross-section and length, to adapt it to such use. III., 1389-90, **5555-60.**

Defendant's **Sawyer-Man Carré carbon lamp** described. III., 1391, **5562.**

Sawyer-Man lamps made by Shallenberger described. III., 1392-5, **5567-79.**

Explains that precautions taken in making these **Sawyer-Man lamps** so as to have tight joints. Says that tests have demonstrated that **the lamp structure is practicable.** III., 1396-9, **5581-93.**

Thinks **Sawyer-Man lamps would cost from eighty cents to one dollar each** and that the **renewal of the burner** could be made at a cost differing not greatly from the cost of a modern lamp. III., 1400-1, **5599-602.**

States that the **vacuum in the Sawyer-Man lamps made by him** has not changed since the lamps were first made and tested. III., 1402, **5605.**

The three-wire and multiple-wire systems which are a modification of multiple series, and the use of **feeding circuits** are the principal improvements made since 1880 which have made central station lighting practicable with continuous currents. III., 1415-6, **5660-1.**

Thinks that the **extent to which electricity is distributed for lighting will to-day compare favorably with gas distribution.** This refers to distance and not to quantity. Believes, however, that present systems of electrical distribution can be made to equal gas distribution in the latter respect when the demand for electric lights calls for it. III., 1417, **5668.**

Lamps of more than 100 ohms resistance would be required for central station distribution in simple multiple arc. There are no central station systems using a current direct from the source which are capable of using lamps of less than 100 ohms resistance, excepting series systems or impracticable multiple wire systems. These statements are made with reference to lamps having an illuminating power about equal to a gas jet, and to a central station having a system of distribution comparable in extent to that of a gas plant. III., 1419, **5673-6.**

Lamps of less than 100 ohms resistance have been and are still used in the Edison central station plant in lower part of New York City. [Note. *This plant has a multiple arc system of distribution with feeders.*] III., 1420, **5679.**

Lamps of less than 100 ohms resistance could be employed in a limited way in a central station plant having a **multiple series** system of distribution. III., 1420, **5680.**

The multiple series system of distribution was known in 1880, but not in any definite application to electrical distribution as a complete working system. III., 1420, **5680.**

Obtained his information for his **experiments on Shallenberger's Sawyer-Man lamps** from **Sawyer-Man Patents** Nos. 205,144 and 210,809. For the **method of treating the carbons** which he adopted, he consulted Sawyer-Man Patent No. 211,262 (McKeesport suit). III., 1424, **5693.**

Never saw a burner of a **commercial lamp** which he was sure had not been subjected to **hydro-carbon treatment.** Such information is difficult to obtain (McKeesport suit). III., 1434, **5731.**

Has made successful lamps having a nitrogen atmosphere at a pressure of one-half to one-eighth of an inch of mercury (McKeesport suit). III., 1438, **5749.**

Compares Shallenberger's Sawyer-Man lamp and the drawing in the Sawyer-Man patent, particularly as to the stop-cock and tube (McKeesport suit). III., 1438-42, **5752-66.**

The clamping of a carbon burner presents no difficulty even from the size shown in Sawyer-Man Patent No. 317,676 down to a fine filament (McKeesport suit). III., 1458, **5830.**

Believes that carbon from **every fibrous substance is improved by treatment** subsequent to carbonization (McKeesport suit). III., 1461, **5844.**

Says that **Shallenberger's Sawyer-Man lamps** Nos. 2 to 5 (Nos. 1 and 6 were broken), which were offered in the McKeesport suit, still show that **they have preserved their vacua** or attenuated atmosphere of nitrogen unimpaired. Admits that the **spark test,** applied to determine this, will give only approximate results. III., 1465-6, **5859-62.**

The transformer system, operated by means of alternating currents, is one improvement in distribution introduced since 1880 which **has made central station lighting possible with lamps of less than one hundred ohms resistance.** III., 1469-70, **5874-7.**

The transformer system was first introduced in 1886, and to-day **operates 500,000 lamps of 16 candle-power.** III., 1470, **5878.**

The transformer system is used by the Westinghouse Co., the Thomson-Houston Co., the Fort Wayne-Jenney Co. and by the Brush Electric Company. III., 1470, **5879.**

Gives results of tests to date on experimental lamps having large burners and platinum leading-in wires, some of which are produced and offered in evidence. These tests show the **practicability of permanently sealing large platinum wires into the glass.** III., 1470-4, **5880-94.**

110-volt lamps would be suited for central station use only in selected districts in large cities. III., 1475, **5898-900.**

Defendants' M lamp could be operated at only three-fourths the distance from the source at which the Zigzag paper lamp could be worked at the same cost and efficiency of distribution. III., 1475-6, **5900-1.**

Explains the reasons why the M lamp and Zigzag paper lamp could not be used in central station lighting in connection with distributing systems which were available prior to 1880. Improvements made in distributing systems since that time are the use of **feeders,** the **three-wire system** and the alternating current **transformer system.** III., 1476-7, **5901-7.**

It is possible to operate lamps at a greater distance from the central station with the transformer system than with continuous current system. III., 1480, **5919.**

THOMSON, Prof. Elihu:

Lamps with **tar-putty burners,** coiled into a spiral and united to platinum wires before carbonization, **have not been made and used commercially.** III., 1496, **5981.**

No lamps, which have had the **burners united to platinum wires before carbonization,** have been made and used commercially. III., 1496, **5982.**

Practical lamps with tar-putty burners, coiled into a spiral and united to platinum wires before carbonization, **could not be made without using inventions not described in the patent in suit and not known at that date.** III., 1496, **5984.**

It would be difficult to make a tar-putty thread of the size mentioned in the specification of the patent in suit, that is, seven one-thousanths of an inch in diameter. III., 1497, **5986.**

The following are some of the **difficulties which would be encountered in attempting to make a tar-putty burner.** A tar-putty thread could not be coiled into spiral form without deforming it. On heating, the tar-putty would soften. During carbonization it would shrink, and the copper spiral on which it is to be coiled would expand. This would rupture the carbon spiral. The tar-putty would tend to cement itself to the copper, and if it were carbonized at the proper heat the copper would melt; this, however, would not overcome the evil resulting from the shrinking of the tar-putty thread because it would become rigid before the copper began to melt. The patent in suit mentions no remedy for these difficulties. III., 1497-8, **5985-90.**

It would be **difficult to make the joint between tar-putty thread and platinum wires** so that it would remain intact during carbonization Some support is essential, and no directions on this point are given in the patent in suit. III., 1498, **5990-2.**

It would be **necessary to wind tar-putty thread on a shrinkable mandril** so that carbonization would be successful. This would be an invention which is not mentioned in patent in suit. III., 1499, **5993.**

A tar-putty thread, or even a common thread, could not be carried through the carbonizing process and result in a closely coiled spiral with the convolutions evenly spaced. They would be liable to touch one another, and **short-circuit** parts of the spiral burner. III., 1499-1500, **5994-7.**

The lumps of tar-putty, which clamp the burner and platinum wires together, **would gradually give out gases** during the use of the lamp which would **spoil the vacuum.** The patent in suit gives no directions for preventing this. Enumerates some attending evils. III., 1500, **5998-9.**

A closely coiled spiral would be raised to a much higher temperature on the interior than on the exterior surface, and the central convolutions would be hotter than those at each end. **This irregular distribution of heat would rapidly destroy the burner.** III., 1500-2, **6000-6.**

Contrary to the statement in the patent in suit, **carbon is not stable in the highest vacuum when the temperature is carried to too high a point.** Evaporation or volatilization then takes place very rapidly. III., 1502, **6006.**

A spiral burner, aside from its disadvantages, supports itself better than a long thin burner and reduces the mechanical strain on the attached supports or leading-in wires. By coiling, a burner can be made of great length and high total resistance with a minimum radiating surface. A spiral would be brought to a much higher temperature than if it were spread out. This is an advantageous result of spiral form, but **all the advantages of the spiral form would be outweighed by the evils.** III., 1502-3, **6008-11.**

The lamp shown in the drawing of the patent in suit could never be made and used commercially. The condition of commercial use is that of supplying, as pointed out in specification of patent in suit, **large numbers in multiple-arc** from the same mains, that is, at the same electro-motive force. Now, lamps like the one referred to could not be made with sufficient uniformity so that, under this condition, a number of them could be operated on one circuit, because they would burn at a varying incandescence—some too low and with poor economy, and others too high, resulting in a short life. **It would be practically impossible to secure uniformity in temperature and illuminating power in lamps made by the methods pointed out in the patent in suit.** III., 1503-5, **6012-7.**

The spiral burner would warp during carbonization, which would destroy uniformity of spacing of the coils. **The joining of the burner to the platinum wires before carbonization would be fatal,** because it prevents adjustment of its resistance in a vacuum. III., 1505-6, **6018-21.**

If what Edison says in his American Association paper, concerning the qualities discovered in platinum by electrically heating it in a vacuum, is true, then **Edison's platinum lamp is a better lamp for com-**

mercial multiple-arc lighting than the one described in the patent in suit. III., 1507-10, **6026-37.**

In view of what was then known of the laws of electricity and of Edison's platinum lamp construction, and assuming that it was known how to make a small carbon burner and how to attach it to the leading-in wires, **it would not have required invention in June, 1879, to substitute carbon for platinum as the material of the burner in an exhausted all-glass globe. Carbon was a well-known substitute for platinum. It was known to have a higher specific resistance than platinum and that it would stand a high temperature without fusion or evaporation when oxygen was excluded. It was well-known how to proportion the diameter and length of a resisting conductor** so that it would be brought to a desired temperature with a definite current or electro-motive force. This knowledge had been made use of in making **fuses** for exploding mines and **eudiometer tubes.** It was also well understood that with a given current, the higher the specific resistance the larger should be the cross-section of the resisting conductor; and that with a given cross-section and electro-motive force, the higher the specific resistance, the shorter should be the length of the conductor. It was also known that restricting the extent of radiating surface by coiling would increase the temperature and modify the above relations. III., 1510-13, **6037-49.**

No new process of making carbon burners for incandescent lamps is described in the patent in suit. The tar-putty process was old in Gaudulu's French patent and addition of 1876 and 1877. This process is described in Fontaine's Electric Lighting. **Shaping of such material before carbonization was old in Scott's provisional specification** of 1878. **Carré's process** of making carbons, which were used for arc and incandescent lighting, consisted in producing a paste or putty made from a mixture of fine carbon and plastic materials, which was moulded into shape and carbonized and subsequently impregnated with a carbonaceous material and then recarbonized. **Pulvermacher,** in British Patent No. 4774 of 1878, describes a method of making a sort of Jablochkoff candle in which the **spiral carbon** is moulded from a paste compounded of powdered charcoal and tar. Thinks that **Edison's process may be new,** if it can be considered that the omission of the impregnation process for increasing the rigidity and density of a carbon rod or pencil is novel. III., 1513-17, **6049-67.**

The patent in suit describes no process of making burners whereby they can be made smaller than by processes described before. It is a question of skillful manipulation. III., 1518, **6069.**

It was not generally recognized that subdivision was solved by the patent in suit. There was no exhibition of lamps made according to the patent. Edison's American Association paper was more calculated to produce such an effect on the public. Quotes from the "Telegraphic Journal" of October 15, 1878, concerning an interview with Edison, in which the "handle of a Ritchie induction coil" figures. **Defines subdivision and says that Edison did not accomplish it. Incandescent lighting to-day hardly competes economically with gas.** Its ability to compete with gas is largely due to improvements in the economical production of power; in the **distribution of the current,** and in the perfection of the lamp. III., 1518-20, **6070-8.**

Does not agree with Prof. Barker that, upon the issue of the patent in suit, capital began at once to embark in electric lighting, which said patent rendered possible. Says that much progress was made prior to 1880, notably in lighting with Jablochkoff candles. Quotes from the **Eleventh Edison Bulletin** concerning the commencement of the regular manufacture of lamps in November, 1880, and from the **Fourteenth Bulletin,** to the effect that the first central station was not started until September, 1882. The growth of the business was very slow after this time. III., 1520-1, **6079-82.**

Does not agree with Prof. Barker that central stations were rapidly installed in this country and in Europe upon the grant of the patent in suit. Refers to **Edison Bulletins** to prove the slow growth in this respect and in respect to the increase in the number of lamps made. III., 1521-2, **6083-6.**

The invention described in the patent in suit was not the creation of a new art. The lamp could not be made and used commercially. The development of incandescent lighting was dependent upon and the consequence of a large number of improvements in dynamos, in **methods of distribution** and regulation, and in improvements in the method of making lamps. Quotes **Edison's testimony in the McKeesport suit** with reference to what was necessary to accomplish subdivision to sustain this opinion. Edison's testimony goes in detail into the **necessity for a proper method of distribution,** a suitable lamp, a meter, a proper system of conductors for supplying current to the houses from a central station, means for regulating this supply under constant electro-motive force, suitable and economical dynamos and steam plant and electric apparatus in the station, and safety devices and electroliers. **Mr. Edison found that all this had to be done before a new art could be created.** Quotes from the **Twenty-first Edison Bulletin** to sustain the correctness of Edison's statements made in McKeesport suit. III., 1522-8, **6087-111.**

The expression **"practical subdivision of the electric light,"** found in the patent in suit, means that the electricity generated at one place is to be **distributed over a considerable area,** so that consumers may obtain lights of about the power of a **gas jet,** and that this distribution is to be accomplished economically to a distance comparable to that at which gas is supplied in cities. The expression involves the idea that the plant must not be too expensive. **This involves the multiple arc system,** in which the main conductors are not excessively large and extensive. It might also be assumed that the idea of **independent control of the lighting and extinguishing of individual lamps,** and the maintaining of an electro-motive force which will keep the lamps at a uniform brilliancy, belong to such a system. III., 1528-9, **6112-4.**

Prior to the patent in suit, if a person had undertaken to distribute electric light in multiple arc, he **would have known that the old incandescent lamps referred to in the patent ought to be made so as to be of high resistance** in order to reduce the size and cost of the main conductors and prevent undue loss of energy in them. Cites the making of **telegraphic relays and fuses of high resistance.** III., 1530, **6115-9.**

The patent in suit indicates that 100 ohms is the least resistance which a lamp embodying the invention must have. The lamp is intended to have sufficient resistance to make it available in accomplishing subdivision economically in a system comparable to that of gas distribution (as stated by Mr. Edison in McKeesport suit), and without calling for conductors of enormous size and cost in order to get uniformity of electro-motive force, and, therefore, a uniform brilliancy in the lights throughout the system irrespective of the number of lamps in use at any one time. As a matter of fact, **100-ohm lamps could not be economically used in a simple multiple arc system on the scale contemplated by Mr. Edison. Even with lamps of 150 and 200 ohms, which have been made and used for a number of years, it is doubtful whether any considerable growth of such a system would have occurred without subsequent inventions.** Even with improvements which have reduced the amount of copper required in the conductors over 60 per cent., the area covered by a central station plant is quite moderate and not to be compared with that covered by gas plants. **The Edison Company finds it necessary to establish central stations at different points over a large city,** in order that the cost of conductors shall not be prohibitory. III., 1532-7, **6127-45.**

Defendants' M and Zigzag lamps, respectively of 40 and 80 ohms resistance when hot, would not be of high enough resistance to allow of the practical subdivision of the electric light in the sense in which that expression is used in the patent in suit without making use of **methods of distribution** devised since the date of the patent. III., 1537, **6147.**

The term "wire," as used in the arts, particularly in electric arts, is generally applied to a length of metal which can be coiled and which is of round section, though square and rectangular sections come under the same definition. The electric arts use "wires" which range from the very finest up to an inch in diameter. **The terms "rod" and "wire" as used in trade or shop nomenclature, do not import the idea that there is any difference in the area of their cross-section.** The terms are sometimes used synonymously, without restriction of any kind. III., 1538-9, **6149-53.**

The **specific resistance of the carbon of an incandescent burner is not dependent upon the fact that the material is reduced to shape before carbonization.** III., 1539, **6154.**

Knows of lamps in practical use which have straight burners, for example, the **Bernstein lamp,** which has been in use since 1882 or 1883. Also a lamp with a **V-burner,** which is a recent production. III., 1539, **6156.**

At the date of the patent in suit the **dynamos and engines then available had defects which would cause the current to fluctuate** so as to seriously impair the steadiness of the light from an incandescent lamp. III., 1540-1, **6158-61.**

The Edison "Pea" and "Municipal" lamps are not adapted for multiple arc use in an extended system of distribution. III., 1541-2, **6162-5.**

After their invention, **the use of Geissler and Sprengel mercury pumps for obtaining a vacuum in King's lamp would have been an obvious thing to do.** King's patent directs the art to seal off the chamber of the **submarine lamp** above the mercury column by fusion of the glass and to seal in the lower leading-in wire in the same manner, this being also the method pursued with respect to the upper leading-in wire. Says that **King contemplated a lamp with a very thin burner of comparatively high resistance,** and that his carbon burner of hard carbon was to be filed down to the desired shape and thinness after being cut out by sawing. III., 1543-5, **6170-8.**

A carbon lamp like **King's submarine lamp** (asserted by Thomson to have an all-glass chamber, with leading wires fused into the glass), if made with the skill extant in January, 1879, **would be a better**

lamp than the tar-putty lamp described in patent in suit. Means were known for obtaining a high vacuum and for producing carbons of the required character. III., 1545-6, **6180-1.**

Attributes **the impulse given to electric lighting in 1878 and 1879** to the telephone, Jablochkoff candle and Gramme and Siemens dynamos. III., 1546-7, **6182-5.**

Says that he heard Prof. **Barker's lecture in Philadelphia in November, 1878,** and that Barker said that he had seen lamps in operation at Edison's laboratory which, to his mind, solved the problem of electric lighting for general use. III., 1547, **6187.**

The lamp described in the specification of the patent in suit would have a burner coiled so as to restrict the amount of radiating surface. The platinum wires would be attached to the burner prior to its carbonization. The burner would be made of thread or tar-putty, and, after carbonization, would be mounted in the lamp globe, which would be exhausted without giving the lamp any treatment to further perfect it before sealing it up. III., 1604, **6413-4.**

Thinks that **the carbon paste clamps described in the patent in suit should be heated to drive off gases,** and that the art would not naturally think of or attend to this, and that it would necessitate a **special process not described.** III., 1605, **6417-8.**

Particularly criticises that part of the process described in the patent in suit, where the **platinum wires are to be attached to the burner prior to its carbonization,** as being **a wrong order of procedure** for obtaining a good result. III., 1606, **6422.**

Thinks that **the statement in the patent in suit about the carbon thread of 100 to 500 ohms resistance indicates that that resistance is not enough,** and that the **spiral burner** was selected in order to obtain a higher resistance which would adapt the lamp to multiple arc distribution. III., 1616, **6465.**

States what parts of the patent in suit he thinks are **mere descriptions of experiments.** III., 1617-18, **6468-74.**

Enters into a complicated and theoretical consideration of the question as to whether the carbon thread (described in the patent in suit as being placed in an exhausted globe and as having from 100 to 500 ohms resistance) is a coiled or a plain thread. [Note. *While considering this question the witness radically changed his opinion upon some points. See pp. 1613 et seq.*] III., 1609-24, **6434-96.**

Admits that, in his answers to questions 6 and 8, where the lamp described in the patent in suit is criticised as never having been used commercially and as being altogether an impracticable lamp, he **did not assume anything not distinctly set forth in the patent, or consider what would have resulted from the exercise of skill and judgment.** Says that **by dispensing with coiling the disadvantages in manipulating tar-putty thread would be lessened.** III., 1625 6, **6500 4.**

Lamps like those of the patent in suit, with leading-in wires attached to the burner before its carbonization, are fixed as to resistance, whereas there should be some means for adjusting this. The hydro-carbon treatment is one way of doing this. This treatment was, broadly speaking, known before the date of the patent in suit as a means for varying the resistance of a carbon conductor, but at that time could not have been applied with the delicacy and skill required in adjusting the resistance of filaments. **The Sawyer-Man process, described in their Patent No. 211,262 of 1879, does not state the requirements which would make it suitable for adjusting the resistance of filaments,** although sufficient as describing a process for solidifying and diminishing the specific resistance of carbon. Says that, even if the Edison Company does not use the hydro-carbon process as a means for equalizing the resistance of its lamps, it does use special methods of carbonization under exact conditions not known at the date of the patent in suit, and, moreover, does not make a prior attachment of the burner to the leading wires; but even under these circumstances the company is **compelled to sort the lamps into groups or batches according to their resistance.** Admits, however, that this sorting process has to be resorted to even by those who use the hydro-carbon process, and that the resistance, which makes this sorting process necessary, varies through quite a range. III., 1627-34, **6506-42.**

Says, as to degree of heat required to carbonize tar-putty, that **1,000 degrees Fahrenheit would result in ordinary carbonization;** that about the temperature of melting platinum would be necessary for **complete carbonization,** but that for ordinary purposes the temperature of melting iron will answer. III., 1640, **6560.**

Considers the **meaning of the language of the patent in suit as to winding or coiling a filament upon or between the coils of a copper helix, and as to the use of a mandril.** Emphasizes some of the difficulties of coiling a filament, but has no positive opinion as to what the directions given in the patent may mean. III., 1643-8, **6569-89.**

Fears that in carbonization, the **tar-putty filament would pull away from the platinum wire** to which it is attached. III., 1649, **6595.**

THOMSON, Prof. Elihu.

Thinks **the burner of the patent in suit is limited to one very closely coiled,** much closer than is shown in the drawing. Arrives at this opinion largely from the statement in the patent that tar-putty filaments can be rolled out over a foot long, but sees no reason why the length should be restricted to a foot, as it might perhaps be greater or very much less. III., 1652-5, **6608-17.**

Thinks that the **tar-putty clamps** of the patent in suit would, because of the low temperature to which they would be subjected during carbonization, **gradually give off gases and lower the vacuum** during the use of the lamp. While this **difficulty might be overcome** by heating the burner to a very high incandescence during exhaustion, he thinks that this procedure would injure the burner. III., 1656, **6621.**

With a **low vacuum,** if the gas is without action on the carbon, the lamp may operate satisfactorily excepting that its **efficiency may be reduced.** Does not know how low a vacuum would have to be to prevent the satisfactory operation of the lamp. III., 1661, **6642-3.**

Considers **Edison's statements concerning his platinum lamp** and the properties which he had conferred on platinum, etc. III., 1663-7, **6652-66.**

In stating that no lamps made according to the patent in suit have ever been used or exhibited, he **excludes the lamps which were exhibited at the date of said patent as not having been made in accordance therewith.** III., 1669, **6673.**

Considers the **"New York Sun" article** of September, 1878, and its repetition in the "Telegraphic Journal;" also **Pope's book** on "Evolution of the Electric Incandescent Lamp." III., 1669-73, **6674-89.**

As to the **establishment of central stations and the embarkation of capital in incandescent lighting,** he obtains his information from the bulletins of the Edison Company. Overlooked the fact stated in one bulletin that before January 26, 1882, between six and seven miles of street mains had been laid in the **New York downtown district.** Does not know how much earlier the financial arrangements for constructing this station were made. Overlooked the fact that the **central station at Holborn Viaduct** was in operation on April 13, 1882, and did not know that the apparatus for it was made in the United States. III., 1673-6, **6690-702.**

Defendant's M lamp, which has a hot resistance of 40 ohms, is **not used in large numbers in multiple arc in isolated plants.** III., 1682, **6726.**

Knows nothing of the **V lamp,** which is in evidence, as to its economy and durability. Does not know that it is in use in this country. III., 1685-6, **6740-3.**

He would have known how to seal off the lamp chamber above the mercury column in order to make **King's submarine lamp.** III., 1689, **6755.**

There was no necessity for **King's patent** to specifically state that the **mercury column is to be omitted.** III., 1689, **6756.**

The first description of the carbon lamp includes a barometer tube dipping in a cup of mercury. III., 1690, **6757.**

The lamp with a mercury column could not be used as a submarine lamp as the water pressure would cause the mercury to rise and fill the lamp chamber. Does not believe that this difficulty could be successfully overcome by putting a cap over the mercury cup. **The statement that the submarine lamp is to be sealed up does not mean that a cap is to be used.** The well-known **stuffing box with packed joint could have been used** to make a seal between the barometer tube and mercury cup, but would be an imperfect device. III., 1690-5, **6758-79.**

If the lamp were sealed by fusion, a **platinum wire would have to be substituted for the copper wire** *n* mentioned in the King patent. It would have naturally been done and the tube would have been constricted at the point of sealing. **The patent does not specifically state that the copper wire** *n* **is to be replaced by a platinum wire.** III., 1696, **6781-3.**

The platinum burner contemplated is to be exceedingly thin, comparable to the thinness of gold leaf. Assuming the thickness to be $\frac{1}{100000}$ of an inch, the resistance of the platinum burner shown in the drawing would be **22 ohms when incandescent,** and 3 ohms when cold. From statements in the specification he figures the resistance as **80 to 90 ohms hot.** III., 1696-9, **6784-93.**

Practically there would be **no more mercury in the sealed submarine lamp than there is in a modern lamp.** III., 1699, **6795.**

The deleterious gases in the lamp chamber might be removed by inverting the mercury column and then restoring the lamp to its original position. III., 1700, **6800.**

For submarine work **the lamp would be sunk by the weight of the conductors or it might be attached to the diver's helmet.** III., 1701, **6802.**

Assuming it possible to make **King's carbon burner** as thin as his platinum burner, the resistance of the former would be several times that of the latter. **Cannot imagine it possible to make such a burner.** III., 1704, **6813,** and 1709, **6835.**

Gas lighting is cheaper than electric lighting in spite of all the improvements which have been made in the latter. III., 1704, **6816.**

THOMSON, Prof. Elihu.

Defendants' M lamp could not be used in simple multiple arc in any scheme of general distribution even over limited areas. Distances of even a few hundred feet would be prohibitory. III., 1705, **6819.**

Thinks that the **tar-putty filament,** if actually supported by the mandril, **would be surely destroyed during carbonization.** III., 1707, **6828.**

Explains why, in his opinion, **arc lights** are so much **more economical than incandescent lights.** III., 1708, **6830.**

Closely **folding a filament back and forth upon itself would restrict the radiating surface** in the same way as close coiling. III., 1708, **6832.**

When the Thomson-Houston Company took up the business of incandescent lighting, the United States Company, Brush-Swan Company, Bernstein Company and Consolidated Company were engaged in the same business. The United States Company were in the field in 1880. III., 1709, **6833.**

VANDEGRIFT, James A. :

Defendant's paper carbon burners, after coming from the furnace and before being subjected to **hydro-carbon treatment,** are too **fragile** to be of any commercial use. III., 1488, **5949.**

Has tried to make paper carbon burners with a high degree of carbonization in the furnace. They were so **fragile** that the specific resistance could not be ascertained. [Note: *This refers to burners not subjected to hydro-carbon treatment.*] III., 1490, **5959.**

<u>Edison Electric Light Co.</u> v. <u>United States Electric Lighting Co.</u>

Volume I

Pleadings, Complainant's Prima Facie Proofs, Decisions

NO. 5.

CIRCUIT COURT OF THE UNITED STATES.

SOUTHERN DISTRICT OF NEW YORK.

IN EQUITY—No. 3445.

THE EDISON ELECTRIC LIGHT COMPANY

vs.

THE UNITED STATES ELECTRIC LIGHTING COMPANY.

ON LETTERS PATENT NO. 223,898.

PLEADINGS, COMPLAINANT'S PRIMA FACIE PROOFS AND DECISIONS RELATING TO THE PATENT IN SUIT.

S. B. EATON,
Complainant's Solicitor.

C. A. SEWARD,
B. F. THURSTON,
R. N. DYER,
Complainant's Counsel.

DUNCAN, CURTIS & PAGE,
Defendant's Solicitors.

C. G. Burgoyne's Printing Business, Cor. Walker and Centre Sts., N. Y.

1

In the United States Circuit Court

FOR THE SOUTHERN DISTRICT OF NEW YORK.

2

THE EDISON ELECTRIC LIGHT COMPANY, Complainant, vs. UNITED STATES ELECTRIC LIGHTING COMPANY, Defendant.	In Equity. No. 3445.

3

TO THE HONORABLE THE JUSTICES OF THE CIRCUIT COURT OF THE UNITED STATES FOR THE SOUTHERN DISTRICT OF NEW YORK.

The Edison Electric Light Company, a corporation duly organized and existing under and by virtue of the laws of the State of New York, and having its principal place of business in the City of New York, brings this its bill of complaint against the United States Electric 4
Lighting Company, a corporation likewise organized and existing under and by virtue of the laws of the State of New York, and having its principal place of business in the City of New York.

And thereupon your orator complains and says:

That, as your orator is informed and believes, prior to the fourth day of November, 1879, Thomas Alva Edison, a citizen of the United States, residing at Menlo Park, in the County of Middlesex and State of New Jersey, was the true, original and first inventor of a

4078

5 certain new and useful improvement in electric lamps, which was not known or used in this country, and not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof, and which was not in public use or on sale more than two years prior to his application for Letters Patent of the United States therefor, and did on the said 4th day of November, 1879, apply to the Commissioner of Patents of the United States for letters patent for said invention or improvement and fully
6 and in all respects complied with all the requirements of the law in that behalf, and especially made oath that he verily believed himself to be the true, original and first inventor of the said improvement, and also paid into the Treasury of the United States the fees required by law, and presented to said Commissioner of Patents a petition setting forth his desire to obtain an exclusive property in said improvement and praying that letters patent might for that purpose be granted unto him; and also delivered and filed in said office of
7 the Commissioner of Patents a written description of his said improvement in such full, clear and exact terms as to enable any person skilled in the art with which the said improvement is most nearly connected to make and use the same, which description was duly signed by the said Thomas Alva Edison and attested by two witnesses.

That upon due examination being made as to the novelty and utility of the said invention or improvement by the Commissioner of Patents, as provided by
8 law, the said Thomas Alva Edison was adjudged to be entitled to letters patent for said invention or improvement, and thereupon the said Commissioner of Patents caused letters patent, bearing date the 27th day of January, 1880, and numbered 223,898, to be made out, issued and delivered to the said Thomas Alva Edison, in due form of law in all respects, in the name of the United States of America, and under the seal of the Patent Office of the United States, and that said letters patent were signed by the Secretary of the Interior of the United States and countersigned by the Commis-

sioner of Patents; and that the said letters patent did 9
grant to the said Thomas Alva Edison, his heirs or assigns, for the term of seventeen years from the date thereof the exclusive right to make, use and vend the said invention throughout the United States and the Territories thereof.

That the said Thomas Alva Edison, on the 12th day of February, 1880, by a certain instrument in writing, duly executed and delivered by him, and bearing date on said last mentioned day, did grant to your orator, its successors and assigns, the entire right, title and inter- 10
est in and to said improvement in electric lamps described in said Letters Patent No. 223,898, granted January 27th, 1880, and in and to said Letters Patent No. 223,898, and that said instrument in writing was duly recorded in the Patent Office on the 24th day of February, 1880.

And your orator further shows, on information and belief, that prior to the 21st day of April, 1879, the said Thomas Alva Edison was the true, original and first inventor of a certain other new and useful im- 11
provement in electric lights, which was not known or used in this country, and not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof, and which was not in public use or on sale more than two years prior to his application for Letters Patent of the United States therefor, and did, on the said 21st day of April 1879, apply to the Commissioner of Patents of the United States for letters patent for said invention or improvement, and fully and in all respects complied 12
with all the requirements of the law in that behalf, and especially made oath that he verily believed himself, to be the true, original, and first inventor of the said improvement, and also paid into the Treasury of the United States the fees required by law, and presented to the said Commissioner of Patents a petition setting forth his desire to obtain an exclusive property in said improvement, and praying that letters patent might for that purpose be granted unto him, and also delivered and filed in said office of the Commissioner of

13 Patents a written description of his said improvement
in such full, clear and exact terms as to enable any
person skilled in the art with which the said improve-
ment is most nearly connected, to make and use the
same, which description was duly signed by the said
Thomas Alva Edison, and attested by two witnesses.

That upon due examination being made as to the
novelty and utility of the said invention or improve-
ment by the Commissioner of Patents, as provided by
law, the said Thomas Alva Edison was adjudged to be
14 entitled to letters patent for said invention or improve-
ment, and thereupon the said Commissioner of Patents
caused letters patent, bearing date the 4th day of May,
1880, and numbered 227,229, to be made out and issued
to the said Thomas Alva Edison, in due form of law in
all respects, in the name of the United States of Amer-
ica, and under the seal of the Patent Office of the United
States, and that said letters patent were signed by the
Secretary of the Interior of the United States and
countersigned by the Commissioner of Patents; and
15 that the said letters patent did grant to the said
Thomas Alva Edison, his heirs or assigns, for the
term of seventeen years from the date thereof, the
exclusive right to make, use and vend the said inven-
tion throughout the United States and the Territories
thereof.

That the said Thomas Alva Edison on the first day
of June, 1880, by a certain instrument in writing, duly
executed and delivered by him and bearing date on
said last mentioned day, did grant to your orator and
16 its successors and assigns, the entire right, title and
interest in and to said improvement in electric lights,
described in said Letters Patent No. 227,229, granted
May 4th, 1880, and in and to said Letters Patent No.
227,229, and that said instrument in writing was re-
corded in the Patent Office on the 11th day of June,
1880.

And your orator further shows, on information and
belief, that prior to the 15th day of December, 1880,
Thomas Alva Edison was the true, original and first
inventor of a certain new and useful improvement in

methods of treating carbons for electric lamps, not 17
known or used in this country, and not patented or de-
scribed in any printed publication in this or any foreign
country before his invention or discovery thereof, and
which was not in public use or on sale more than
two years prior to his application for Letters Patent
of the United States therefor, and did on the said 15th
day of December, 1880, apply to the Commissioner of
Patents of the United States for letters patent for said
invention or improvement, and fully and in all respects
complied with all the requirements of the law in that 18
behalf, and especially made oath that he verily be-
lieved himself to be the true, original and first inventor
of the said improvement, and also paid into the Treas-
ury of the United States the fees required by law, and
presented to the said Commissioner of Patents a peti-
tion setting forth his desire to obtain an exclusive
property in said improvement, and praying that letters
patent might for that purpose be granted unto him;
and also delivered and filed in said office of the Com-
missioner of Patents a written description of his said 19
improvement, in such full, clear and exact terms as to
enable any person skilled in the art with which
the said improvement is most nearly connected to
practice the same, which description was duly signed
by the said Thomas Alva Edison and attested by two
witnesses.

And that the said Thomas Alva Edison, on the 21st
day of June, 1881, and before the issuing of the letters
patent next hereinafter mentioned, by an instrument
in writing duly executed and delivered by him, and 20
bearing date on the last day named, did assign to your
orator, and its successors and assigns, all the right,
title and interest whatever in and to the said improve-
ment in methods of treating carbons for electric lamps,
and any Letters Patent of the United States that might
thereafter be granted therefor, and that said instrument
in writing was duly recorded in the Patent Office of the
24th day of June, 1881.

That upon due examination being made as to the
novelty and utility of the said last-mentioned im-

21 provement by the Commissioner of patents, as provided by law, upon application for letters Patent made as before set forth by the said Thomas Alva Edison, your orator, as the assignee of said Edison, was adjudged to be entitled to letters patent for the said invention or improvement, and thereupon the said Commissioner of Patents caused letters patent, bearing date the 10th day of October, 1882, and numbered 265,777, to be made out and issued to your orator, in due form of law in all respects, in the name of the United States
22 of America, and under the seal of the Patent Office of the United States, and that said letters patent were signed by the Secretary of the Interior, and countersigned by the Commissioner of Patents; and that said letters patent did grant unto your orator, its successors and assigns, for the term of seventeen years from the date thereof, the exclusive right to practice the said invention throughout the United States and the Territories thereof.

That your orator is now the sole and exclusive owner
23 of the three letters patent before mentioned, and of all claims for infringement or violation thereof, and is entitled to sue for and receive said claims to its own use.

And your orator further shows that the improvements described in all three of said Letters Patent Nos. 223,898, 227,229 and 265,777, and covered by the claims thereof respectively, are capable of use, and are in fact used by your orator and the defendant in one and the same electric lamp for giving light by electrical incan-
24 descence.

And your orator further shows that it has expended large sums of money in the perfecting of said inventions and in the introducing of the same into public use, and that the same are of great public utility and have made practical and commercial the subdivision of the electric light, and the construction of practical and commercial lamps for giving light by electrical incandescence, which before the invention or discovery by the said Thomas Alva Edison, of the improvements covered by said letters patent, had not been accom-

plished, and that before the said inventions or dis- 25
coveries by the said Edison lighting by electrical incandescence had been only a subject of laboratory experiment, and was not in any way practical or commercial. That the fact that said Edison was the original and first inventor of said inventions, and that the patents above named are good and valid patents has been generally recognized and acknowledged by those who have used the inventions, and the public generally in all parts of the United States, and the claims of the said Edison and your orator and its licensees of the 26
exclusive right to the said inventions under said patent have been generally acknowledged and acquiesced in.

That over six hundred thousand of such electric incandescent lamps have been used in the United States under license from your orator, and that there are now in use in the United States more than one hundred and twenty thousand of such electric incandescent lamps licensed by your orator, and that nothing which the defendant or its employees, associates or assignors, 27
and especially Hiram S. Maxim or Edward Weston, has done, has contributed in any substantial way to the development or perfection of electric incandescent lamps, or the introduction thereof into general use, and that but for the infringement, misrepresentations and wrongs hereinafter complained of, your orator would now be in the peaceful possession and enjoyment of said letters patent and inventions, and of the income derivable therefrom.

And your orator further shows that said defendant 28
hereinbefore named, as your orator is informed and believes, having notice of said three letters patent and well knowing all the facts hereinbefore set forth, but contriving to injure your orator and to deprive it of the benefit and advantage which might and otherwise would accrue to it from said inventions, without the license of your orator, against its will and protest, and in violation of its rights and of said letters patent and each of them, has made, sold and used, and caused be made, sold and used, is now making, selling and

29 using, and causing to be made, sold and used, and intends still to continue to make sell and use, and cause to be made, sold and used incandescent electric lamps, embodying and involving the use of the improvements covered by said three letters patent, and each of them, or substantial or material parts of them and each of them, and has infringed the said letters patent and each of them as aforesaid, and is now infringing the same in the Southern District of New York and elsewhere by making, selling and using, and causing to be made, sold
30 and used as aforesaid in the Southern District of New York and elsewhere the improvements covered by said letters patent and each of them, or substantial or material parts of them and each of them, but precisely how long the defendant has made, sold and used the said several improvements, and to what extent it has made, sold and used them, your orator for want of a discovery thereof does not know and cannot set forth, and prays that the defendant may be compelled to set forth the same in its answer.

31 And that by reason of said infringement of said letters patent and each of them, as aforesaid, great injury has resulted to your orator, and great gains and profits have accrued to said defendant, the full amount of which is unknown to your orator; but your orator avers, on information and belief, that the defendant has so made and used, and caused to be made and used, a large number of such incandescing electric lamps, and that it has derived large profits therefrom, and that your orator has been deprived of large gains
32 and profits by reason of the aforesaid infringement of the defendant, and has thus suffered large damages therefrom.

And your orator further alleges, upon information and belief, that as to said letters patent and each of them the defendant may wrongfully claim or pretend, as an excuse for the continuance of its wrongful acts in the premises, that said letters patent and each of them are no longer in force or operative, because at the time they and each of them were granted to the said Thomas Alva Edison as aforesaid, the inventions or improvements on

such several letters patent described and protected had 33
been first patented or caused to be patented by him in certain foreign countries, that is to say, the invention and improvement described and protected in Letters Patent No. 223,898, had been patented in the Dominion of Canada, by a patent issued therein under date of November 17, 1879; the invention and improvement described and protected in Letters Patent No. 227,229 had been patented in the Kingdom of Italy by a patent issued therein under date of June 30th, 1879, and the invention described and protected in Letters Patent 34
No. 265,777 had been patented in the Austro-Hungarian Empire by a patent issued therein under date of October 12th, 1882.

That as to said foreign patents the defendant may wrongfully claim and pretend that the Canadian patent aforesaid was granted for the term of five years from its date and has expired, and that the Italian patent aforesaid was granted for the term of six years from its date and has expired, and that the Austro-Hungarian patent aforesaid was granted for the term of one year from its 35
date and has expired, and that under Section 4887 of the Revised Statutes of the United States the terms of the said United States patents, and each of them, should be limited to the terms of said foreign patents respectively.

And your orator, in reply to and in explanation of such wrongful claim, if made, alleges that the said Thomas Alva Edison was, at the time of the making of the inventions or improvements described and claimed in the said Letters Patent Nos. 223,898, 227,229, 265,- 36
777, respectively, is now, and always has been, a resident and citizen of the United States, and that the said inventions and each of them were made, perfected and reduced to practice by him therein. That at and for some time prior to the making thereof the said Edison had been conducting, at Menlo Park, in the State of New Jersey, and elsewhere, an extensive series of experiments and investigations with the view of inventing a complete system of electric lighting by incandescence, which should be capable of competing

37 with other forms of illumination and adaptable to general use. That the invention of such a system necessitated the perfection of several distinct apparatus, such as machines for generating the electricity, conductors for conveying it to the translating devices, instruments for regulating automatically and otherwise the pressure and quantity of the current, meters for measuring and recording its consumption, lamps for converting it into light, sockets and holders for supporting the lamps, with many other devices and things
38 necessary to be used in such a system, each machine, apparatus or part being perfected only after many experiments, and frequently embodying several distinct and separate inventions. That in the conduct of said experiments it was necessary for him to expend a large sum of money and employ numerous workmen and assistants. That the laboratory of the said Edison was visited daily by numerous people, and his experiments and inventions were the subject of daily discussion in the public press and in the scientific world, both
39 here and abroad, and were watched closely by those interested in the art and those antagonistic to its development both in America and Europe. That from the extensive scale of his experiments and the interest and discussion they created, it was impossible for him to conceal what he was doing, and in order to protect his interests it became necessary for him, as inventions were made, to at once apply for Letters Patent of the United States thereon, which he uniformly did, and which the said Edison was required to do accord-
40 ing to the contracts made between him and the parties advancing the moneys necessary for the conduct of such experiments and the procuring of such letters patent. And in order that he might secure for such inventions such protection (besides and in addition to such protection as was applied for under the laws of the United States as aforesaid) as the laws of foreign countries gave to alien inventors, it was equally necessary he should promptly apply for letters patent abroad, which he was likewise under contract to promptly do, any delay in doing which would have

been attended with serious danger, as by the laws of 41
many foreign countries no valid patent would or could be granted to the said Edison, on any invention patented and published in the United States prior to the filing of said foreign application, and moreover, as rival inventors, both here and elsewhere, were kept informed of his progress, and were quick to avail themselves of any information they obtained as to his inventions by applying for letters patent thereon in their own name and for their own benefit.

That the said Edison was advised by his counsel, 42
learned in the law, that his interests could only be protected by at once filing his application for domestic patents as inventions were made by him, and immediately thereafter filing applications for foreign patents thereon, and prosecuting such application *pari passu* both here and abroad.

That in no case was any application filed abroad prior to its filing here, but always subsequently, and in no case was the granting of any foreign patent prior to the issuance of the United States Patent on the same 43
invention obtained by the desire of the said Edison or because of any delay in prosecuting his domestic application, but in every case where the foreign patent preceded the United States Patent it was due and owing solely to the different degree of diligence and different course of procedure prevailing in the administration of the patent laws here and abroad.

That the application resulting in said Letters Patent No. 223,898 was filed in the United States Patent Office on the 4th day of November, 1879, as aforesaid, and 44
that the application for Letters Patent of the Dominion of Canada, which said letters patent the defendant may wrongfully claim and allege cover the same invention and improvement as is protected by said Letters Patent No. 223,898, was not filed with the proper authorities of said Dominion until the 8th day of November, 1879.

That the application resulting in said Letters Patent No. 227,229 was filed in the United States Patent Office as aforesaid, on the 27th day of April, 1879, and that the application for letters patent of the Kingdom

45 of Italy, which said letters patent the defendant may wrongfully claim and allege cover the same invention and improvement as is protected by said Letters Patent No. 227,229, was not filed with the proper authorities of said Kingdom until the 11th day of June, 1879.

That the application resulting in said Letters Patent No. 265,777 was filed in the United States Patent Office as aforesaid, on the 15th day of December, 1880, and that the application for letters patent of the Austro-Hungarian Empire, which said letters patent the
46 defendant may wrongfully claim and allege cover the same invention and improvement as is protected by said Letters Patent No. 265,777, was not filed with the proper authorities of said Empire until the 12th day of May, 1881.

That, as your orator is informed and believes, the said Edison was advised by his counsel learned in the law, and it was generally accepted at the time as the law, that Section 4887 of the Revised Statutes of the United States applied solely to inventions made abroad
47 and had no reference or application to domestic inventors prosecuting their rights in foreign countries after the filing of their applications in the United States, and that under said law the said Edison was not bound to elect between a full term here with protection in a limited foreign territory and the alternative of protection in an enlarged foreign territory with a limited domestic term.

And your orator, therefore, denies as matter of law, that under the circumstance aforesaid, even if the said
48 Letters Patent Nos. 223,898, 227,229, 265,777, or either of them, were granted subsequent to the issuing of any foreign patent on said inventions, or either of them, which has since expired, the said letters patent, or either of them, would be limited thereby.

And your orator, upon information and belief, denies as matter of fact, that any foreign patent on the inventions set out and described in said Letters Patent Nos. 223,898, 227,229 and 265,777, or either of them, has expired, or that the original term of any such foreign patent has expired, or that the said Letters Patent Nos.

223,898, 227,229 and 265,777, or either of them, has expired or become nugatory by reason thereof. 49

And your orator specifically denies that any letters patent of the Dominion of Canada covering the inventions set out and described in said Letters Patent No. 223,898 were granted for the legal term of five years and have expired, or that the original term of any such Canadian patent has expired, or that said Letters Patent No. 223,898 have expired or become nugatory by reason thereof; but, on the contrary, complainant alleges that said Canadian patent was granted for the 50
legal term of fifteen years from its date and is in full force and effect.

And your orator specifically denies that any letters patent of the Kingdom of Italy covering the invention set out and described in said Letters Patent No. 227,229 were granted for the legal term of six years and have expired, or that the original term of any such Italian patent has expired, or that said Letters Patent No. 227,229 have expired or become nugatory by reason thereof; but, on the contrary, complainant alleges 51
that said Italian patent was granted for the legal term of fifteen years from its date, and is in full force and effect.

And your orator specifically denies that any letters patent of the Austro-Hungarian Empire covering the invention or improvement set out and described in said patent No. 265,777 were granted for the period of one year and have expired, or that the original term of such Austro-Hungarian patent has expired, or that said Letters Patent No. 265,777 have expired or become 52
nugatory by reason thereof; but, on the contrary, complainant alleges that said Austro-Hungarian patent was for the legal term of fifteen years from its date, and is in full force and effect.

And your orator prays your Honors to grant unto your orator a permanent writ of injunction, issuing out of and under the seal of this Honorable Court, directed to the said United States Electric Lighting Company and strictly enjoining it and its officers, agents and employees not to make, or use, or sell, or cause to be

53 made, used or sold, any incandescing electric lamps containing or employing the invention covered by said Letters Patent Nos. 223,898 and 265,777, or any one of them, or to employ the invention covered by said letters patent, or any one of them, in the manufacture of incandescing electric lamps.

And your orator further prays that the defendant by a decree of this Court may be decreed to account for and pay over to your orator all such gains and profits resulting to it from said infringements of said letters
54 patent, or any of them, and also that the defendant may be decreed to pay all the damages which your orator has incurred or shall have incurred on account of defendant's infringements of said letters patent or any one of them, and also that the defendant may be decreed to pay the costs of this suit, and that your orator may have such other or further relief as the equity of the case or the statutes of the United States may require and to your Honors shall seem meet.

To the end, therefore, that the said defendant may,
55 if it can, show why your orator should not have the relief herein prayed, and may, upon the oath of its proper officers, and according to the best and utmost of their knowledge, remembrance, information or belief, full, true, direct and perfect answer make to all and singular the matters hereinbefore stated and charged as fully and particularly as if the same were here repeated, and they especially interrogated as to each and every of said matters, and more especially may answer, discover and set forth whether during any, and at what
56 period of time, and whether in the Southern District of New York or elsewhere, and when and where they have used said improvements, or any one of them, and whether they have manufactured or sold, or used, or caused to be manufactured, sold or used in said district, or elsewhere, any incandescing electric lamps containing or employing the inventions covered by said Letters Patent Nos. 223,898, 227,229 and 265,777, or any one of them, or whether they have employed the invention covered by said letters patent in the manufacture of incandescing electric lamps; and how many

such lamps they have made or sold, and to whom they have sold the same, and how and of what material the said lamps and the several parts thereof are and have been constructed. 57

May it please your Honors to grant unto your orators a writ of *subpœna ad respondendum*, issuing out of and under the seal of this Honorable Court and directed to the said United States Electric Lighting Company, and commanding it to appear and make answer to this bill of complaint, and to perform and abide by such decree herein as to your Honors shall seem meet. 58

THE EDISON ELECTRIC LIGHT COMPANY,
By EDWARD H. JOHNSON,
Vice-President.

JOHN C. TOMLINSON,
Solicitor for Complainant.
WILLIAM M. EVARTS,
JOHN C. TOMLINSON,
RICHARD N. DYER.
Of Counsel. 59

STATE OF NEW YORK, }
County of New York, } ss.:

On this eleventh day of June, 1886, before me personally appeared Edward H. Johnson, above named, and made oath that he is Vice-President of said The Edison Electric Light Company; that he has read the foregoing bill subscribed by him and knows the contents thereof, and that the same is true of his own 60 knowledge, except as to matters which are therein stated to be based on information and belief, and as to those matters he believes it to be true.

EDWARD H. JOHNSON.

Subscribed and sworn to before me this 11th day of June, 1886.

BERNARD J. KELLY,
[SEAL.] Notary Public,
New York Co.

61 UNITED STATES CIRCUIT COURT,

SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY,
Complainant,

vs.

62 THE UNITED STATES ELECTRIC LIGHTING COMPANY,
Defendant.

In Equity.
No. 3445.

The plea of The United States Electric Lighting Company, defendant, to the amended bill of complaint of The Edison Electric Light Company, complainant:

This defendant, by protestation, not confessing or
63 acknowledging the matters and things in and by said amended bill set forth and alleged to be true, in such manner and form as the same are therein and thereby set forth and alleged, but, on the contrary, protesting that all of the matters and things set forth and alleged in the said amended bill, and particularly the matters introduced into it by way of amendment of the original bill, are immaterial and unnecessary to be answered unto, except as herein answered by plea, for plea to the whole of said amended bill, says that it is informed,
64 and verily believes, that prior to the granting of Letters Patent No. 223,898, mentioned in the said amended bill, the alleged invention or discovery described and claimed in said letters patent had been patented by the Thomas Alva Edison mentioned in said amended bill, or with his knowledge, consent and procurement, in sundry foreign countries; that the one of said foreign patents having the shortest term was a public patent of the Dominion of Canada, and was granted by the said Dominion to the said Thomas Alva Edison on the 17th day of November, 1879, bearing date as of that day,

and being numbered 10,654; that the term for which 65
said Canadian patent was granted was five years from its said date, and expired on the 17th day of November, 1884; that the said Canadian patent was existing and unexpired when the said United States Letters Patent No. 223,898 were granted, but the term thereof expired on the 17th day of November, 1884, and before the commencement of this suit, and thereby the said Canadian patent then expired within the meaning of Section 4887 of the Revised Statutes, the statute in such case made and provided; and that by reason of 66
the premises the said United States Letters Patent No. 223,898 had expired by operation of law prior to the bringing of this suit.

And this defendant further avers, upon information and belief, that subsequently to the grant of the said Letters Patent No. 223,898, viz., on or about the 17th day of November, 1883, the said Thomas A. Edison, with the knowledge, consent and concurrence of the complainant herein, and by its procurement, by a petition in writing tendered the said letters 67
patent to the Commissioner of Patents for correction, in substance alleging as error that the said letters patent had not been limited on their face to the term of the foreign patent for the same invention granted prior to the date of the said United States patent and having the shortest term, and requesting that the said Commissioner would so limit the term thereof that it would expire at the same time with that one of the several foreign patents named by the said Edison in his said petition which had the shortest time to run; that the 68
foreign patents thus named by the said Edison were British patent dated November 10, 1879, No. 4576; Canadian patent dated November 17, 1879, No. 10,654; Belgian patent dated November 29, 1879, No. 49,884; Italian patent dated December 6, 1879, and French patent dated January 20, 1880, No. 133,756; and that the one of the said foreign patents having the shortest term was the said Canadian patent, No. 10,654, dated November 17, 1879, being a patent which, as above set forth, was granted for five years and whose term was

69 limited to expire November 17, 1884. And this de-
fendant in like manner avers that thereupon and there-
after, viz., on or about the 18th day of December, 1883,
the Commissioner of Patents, with the approval of the
Acting Secretary of the Interior, corrected the said
letters patent by endorsing thereon in due form a cer-
tificate to the effect that, in compliance with the request
of the said Edison, the said letters patent were thereby
limited so as to expire at the same time with that one
of the said several foreign patents having the shortest
70 time to run, being, as above set forth, the said Canadian
patent, and that the Commissioner of Patents, as this
defendant is informed and believes, caused correspond-
ing entries to be made in the various files and records
of the Patent Office pertaining to the said letters pat-
ent, and that by the said acts of the Commissioner of
Patents and the Secretary of the Interior the said Let-
ters Patent No. 223,898, which in terms were granted
originally for the term of seventeen years, were specifi-
cally limited on their face so as to expire on the 17th
71 day of November, 1884, prior to the bringing of this
suit.

And this defendant further says that it is informed
and verily believes that prior to the granting of the
Letters Patent No. 227,229, mentioned in the said
amended bill, the alleged invention or discovery de-
scribed and claimed in said letters patent was patented
by the said Edison, or with his knowledge, consent and
procurement in sundry foreign countries; that the one
of the said foreign patents having the shortest term
72 was a public patent of the Kingdom of Italy, and was
granted by the said kingdom to the said Edison on the
23d day of June, 1879; that the term for which said
Italian patent was granted was six years from the 30th
day of June, 1879, and expired on the 30th day of
June, 1885; that the said Italian patent was existing
and unexpired when the said United States Letters
Patent No. 227,229 were granted, but the term thereof
expired on the 30th day of June, 1885, and before the
filing of the amended bill of complaint herein, and be-
fore the date at which this defendant was required by

law to make answer to the original bill of complaint 73
herein, and thereby the said Italian patent then
expired within the meaning of Section 4887 of the
Revised Statutes, the statute in such case made and
provided; and that by reason of the premises the
said United States Letters Patent No. 227,229 had
expired by operation of law prior to the filing of the
amended bill of complaint herein, and prior to the
time at which this defendant was required by
law to make answer to the original bill of complaint
herein.

And this defendant further says that it is informed, 74
and verily believes, that prior to the granting of Letters
Patent No. 265,777, mentioned in the said amended bill,
the alleged invention or discovery described and claimed
in said letters patent had been patented by the said
Edison, or with his knowledge, consent or procure-
ment, in sundry foreign countries: that the one of said
foreign patents having the shortest term was a public
patent of the Austro-Hungarian empire, and was
granted by the said empire to the said Edison on the 75
3d day of August, 1881, and bore date on that day;
that the term for which the said Austro-Hungarian
patent was granted was one year from its said date,
and expired on the 3d day of August, 1882; that subse-
quently, by grant made on the 20th day of August,
1882, said patent was extended for a new term of one
year, and said extended term expired on the 3d day of
August, 1883; that the said extended Austro-Hun-
garian patent was existing and unexpired when the
said United States Letters Patent No. 265,777 were 76
granted, but the term thereof expired on the 3d day of
August, 1883, and before the commencement of this
suit, and thereby the said Austro-Hungarian patent
then expired within the meaning of Section 4887 of the
Revised Statutes, the statute in such case made and
provided; and that by reason of the premises the said
United States Letters Patent No. 265,777 had expired
by operation of law prior to the bringing of this suit.

And this defendant denies that the said Canadian,
Italian and Austro-Hungarian patents, or either of

77 them, were granted for the term of fifteen years, and it also denies that either the said Canadian or the said Austro-Hungarian patent was in full force and effect when this suit was brought, and that the said last named patents, or either of them, or the said Italian patent, was in full force and effect when the amended bill herein was filed, but, on the contrary, by way of denial of each and every allegation in that regard in the said amended bill of complaint contained, this defendant specifically avers that the said Canadian, the said
78 Italian and the said Austro-Hungarian patent, being the patents referred to in said amended bill as covering respectively the inventions set out and described in said United States Letters Patent, Nos. 223,898, 227,229 and 265,777, were granted, the said Canadian patent for the term of five years, the said Italian patent for the term of six years, and the said Austro-Hungarian patent for the term of one year: that the original term of said Canadian patent and of said Austro-Hungarian patent, as also the aforesaid extended term
79 of said Austro-Hungarian patent, and the said Canadian and Austro-Hungarian patents, had expired prior to the bringing of this suit; and by reason of the premises the said United States patents Nos. 223,898 and 265,777 also had expired and become nugatory prior to the bringing of this suit; that the original term of said Italian patent, and the said Italian patent, expired on the 30th day of June, 1885, and before the date at which the amended bill herein was filed, and before the date at which this defendant was required by law
80 to make answer to the original bill of complaint; and that by reason of the premises the said United States patent No. 227,229 also expired and became nugatory on the 30th day of June, 1885, before the date at which the amended bill of complaint herein was filed, and before the date at which this defendant was required by law to make answer to the original bill of complaint.

And this defendant avers that by reason of the premises this Court has no jurisdiction, and ought not to take cognizance of or entertain this suit, and that the complainant, if it has any lawful demand against

this defendant, has a plain, adequate and complete remedy at law. 81

All which matters and things this defendant does aver to be true, and pleads the said expiration of said patents, and each of them, and the expiration of the respective terms thereof, to the jurisdiction of this Court, and prays the judgment of this Court whether it ought to be required to make any other or further answer to the said amended bill, and prays to be hence dismissed with its costs and charges in that behalf most wrongfully sustained.

DUNCAN, CURTIS & PAGE, 82
Solicitors for Defendant.

The undersigned, of counsel for the defendant in the above-entitled cause, hereby certifies that in his opinion the foregoing plea is well founded in point of law.

(Sgd.) SAMUEL A. DUNCAN.

New York, August 4, 1886.

83

STATE OF NEW YORK, }
City and County of New York, } ss.:

PH. TEWKOBBIE, being duly sworn, deposes and says that he is treasurer of the United States Electric Lighting Company, the defendant in the above-entitled suit, and that the foregoing plea is not interposed for the purpose of delay, and the same is true in point of fact.

PH. TEWKOBBIE. 84

Sworn to before me this 4th }
day of August, 1886. }

ROBT. F. GAYLORD,
[SEAL.] Notary Public,
N. Y. Co.

85

CIRCUIT COURT OF THE UNITED STATES,

86 SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY vs. UNITED STATES ELECTRIC LIGHTING COMPANY.	In Equity. No. 3445.

87

The defendant having filed his plea to the bill of complaint herein, now, on motion of John C. Tomlinson, complainant's solicitor, it is

Ordered, that said plea be and the same is hereby set down for argument at the present Term of this Court.

Dated New York, January 13, 1887.

88

At a Stated Term of the Circuit Court of the United States, held in and for the Southern District of New York, at the Court Room in the Post-office building, in the City of New York, on the 31st day of May, 1888. 89

Present—HON. WM. J. WALLACE, Circuit Judge.

THE EDISON ELECTRIC LIGHT COMPANY, 90 Complainant, vs. THE UNITED STATES ELECTRIC LIGHT COMPANY, Defendant.	In Equity. No. 3445.

91

The plea filed by the defendant to the bill of complaint of the complainant herein having been set down by the complainant for argument, and such argument coming on to be heard upon the said bill and plea, and after hearing Edmund Wetmore, Frederic H. Betts and Sam'l A. Duncan, of counsel for defendant in support of said plea, and William M. Evarts, Clarence A. Seward and John C. Tomlinson, of counsel for complainant, in opposition thereto, and due deliberation being 92
had, now, on motion, it is

Ordered, that the said plea be and the same hereby is allowed; and

It is further ordered, that the complainant have one day in which to file its replication thereto; and

It is further ordered, that the times for taking testimony under said bill and plea be apportioned as follows:

(1) That the defendant have until the 15th day of July, 1888, in which to make proof under its plea;

93 (2) That the complainant have from the 15th day of July, 1888, to the 1st day of September, 1888, in which to offer its proof in reply; and

(3) That the defendant have from the 1st day of September, 1888, until the 1st day of October, 1888, in which to offer testimony in rebuttal.

WM. J. WALLACE.

Form approved.

JOHN C. TOMLINSON,

SAMUEL A. DUNCAN.

94

CIRCUIT COURT OF THE UNITED STATES,

SOUTHERN DISTRICT OF NEW YORK.

95 THE EDISON ELECTRIC LIGHT COMPANY

vs. — In Equity. No. 3445.

UNITED STATES ELECTRIC LIGHTING COMPANY.

The replication of The Edison Electric Light Company, complainant, to the plea of United States Electric Lighting Company, defendant.

96 This replicant, saving and reserving unto itself now and at all times hereafter, all and all manner of benefit and advantage of exception which may be had or taken to the manifold insufficiencies of the said plea, for replication thereunto says that it will aver, maintain and prove its said bill of complaint to be true, certain and sufficient in law to be answered unto, and that the said plea of the said defendant is uncertain, untrue and insufficient to be replied unto by this replicant. Without this that any other matter or thing whatsoever in the said plea contained, material or effectual in the law to

be replied unto, and not herein and hereby well and sufficiently replied unto, confessed or avoided, traversed or denied, is true. All which matters and things this replicant is now and will be ready to aver, maintain and prove as this Honourable Court shall direct, and humbly prays as in and by its said bill it has already prayed. 97

JOHN C. TOMLINSON,

Complainant's Solicitor.

Dated May 17th, 1888.

[ENDORSED:] 98

U. S. Circuit Court, Southern District of New York. In Equity. No. 3445. The Edison Electric Light Company vs. United States Electric Lighting Company. Replication. John C. Tomlinson, Complainant's Solicitor, 40 Wall street, N. Y. City. U. S. Circuit Court. Filed May 31, 1888. John A. Shields, Clerk.

UNITED STATES CIRCUIT COURT, 99

SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY

vs. — In Equity. No. 3445. 100

THE UNITED STATES ELECTRIC LIGHTING COMPANY.

SAME

vs. — In Equity. No. 3450.

SAME.

101

Same vs. Same. — In Equity. No. 3449.

102

Same vs. Same. — In Equity. No. 3452.

103

Same vs. The United States Illuminating Company. — In Equity. No. 3453.

104

Same vs. Same. — In Equity. No. 3458.

Same vs. Same. — In Equity. No. 3457.

105

Same vs. Same. — In Equity. No. 3460.

106

Same vs. The National Park Bank. — In Equity. No. 3438.

107

Same vs. Same. — In Equity. No. 3443.

108

Same vs. William G. Mortimer and Richard Mortimer, as Trustees, &c. — In Equity. No. 3483.

Same vs. Same. — In Equity. No. 3488.

109

SAME vs. SAME.	In Equity. No. 3487.

It appearing in each of the above-entitled causes that the pleas filed therein by each of the defendants
110 to the bills of complaint having been set down by the complainant for argument, and such argument having come on to be heard before me upon the said bills and pleas, and that Edmund Wetmore, Frederic H. Betts and Samuel A. Duncan, of counsel for defendants, were heard in support of said pleas; and William M. Evarts, Clarence A. Seward and John C. Tomlinson, counsel for complainant, were heard in opposition thereto, and due deliberation having been had thereon, it was ordered and adjudged by me that said pleas and each
111 of the same be allowed, and that the complainant in each of said causes have one day from the date of said order in which to file its replication thereto in each of said causes; and that the time for taking testimony under said bills and said pleas or under each of said bills and each of said pleas be apportioned as follows: That the defendant in each of said causes have until the 15th day of July, 1888, in which to make proof under its plea; that the complainant in each of said causes have from the 15th day of July, 1888, to the 1st
112 day of September, 1888, in which to offer its proof in reply, and that the defendant have from the 1st day of September, 1888, until the 1st day of October, 1888, in which to offer testimony in rebuttal; and

It further appearing that since the filing of said order in each of said causes the complainant in each of said causes filed its replication to each of said pleas, and that testimony has been taken by both complainant and defendant in each of said causes under said pleas; and

It further appearing that since the said interlocutory

order and decree was passed the law of the land govern- 113
ing the question therein considered and adjudicated has been so far changed under the judicial authority of the Supreme Court of the United States as that the declaration of Section 4887 of the Revised Statutes of the United States that "every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent or, if there be more than one, with the one having the shortest term," does not
mean that the patent so granted shall expire at the 114
same time with the term for which the foreign patent was, in fact, limited at the time the United States Patent was granted, and upon which construction said pleas were allowed, but that it means that it shall expire when the foreign patent expires without reference to the limitation of the term of such foreign patent in actual force at the time the United States Patent was granted.

Whereupon it is ordered and adjudged that the defendants in each of said causes be and they are hereby 115
ordered to appear before one of the Judges of this Court, at the City of New York, on the 1st day of February, 1889, at 11 o'clock in the forenoon, and then and there to show cause why the complainant in each of said causes should not be permitted to withdraw its replications to each of said pleas, and also to show cause why a rehearing and reargument upon the sufficiency of said pleas should not be had, together with such other relief as may be just and proper in the
premises; and that a copy hereof be served upon the 116
solicitors for each of said defendants on or before the 26th day of January, 1889.

WM. J. WALLACE.

117 UNITED STATES CIRCUIT COURT,

SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY vs. THE UNITED STATES ELECTRIC LIGHTING COMPANY.	In Equity. No. 3445.

118

In view of the recent decision of the Supreme Court of the United States in *Bate Co. vs. Hammond*, and the pending order to show cause, etc., and the proposed motion of complainant for leave to amend its bill by striking out all reference therein to Patents Nos. 227,229 and 265,777, and in order to protect the rights of the parties and to simplify proceedings and save time and expense, it is hereby stipulated by and between
119 the parties hereto as follows:

1. The bill herein shall be considered as amended by striking out all reference therein to Patents No. 227,229 and No. 265,777, and all further proceedings herein shall be based upon and be had only under the Patent No. 223,898 set up in the bill.

2. The defendant shall file an answer to the merits of that part of the bill which relates to the said Patent No. 223,898, on or before the first Monday of April, 1889.

120 3. The plea heretofore filed herein shall be considered as amended by withdrawing therefrom all the matter therein contained which relates specially to Patents No. 227,229 and No. 265,777; and the replication heretofore filed to the said plea shall stand *nunc pro tunc* as the replication to the plea as thus amended.

The plea as thus amended is to stand as a special answer to be heard at the same time with the answer on the merits; and the complainant shall not be obliged to file exceptions thereto for sufficiency, but all matters and things therein contained shall be considered as sufficiently excepted to by the general replication of

the complainant to said answer when filed; it being the 121
intent of this portion of this stipulation to save to the defendant at the hearing on the merits the full benefit of said plea and to reserve to the complainant the right at the hearing on the merits both to contest the truth of the said plea and to raise the question of the sufficiency thereof.

It is further stipulated that if at the hearing of said answer and plea at the Circuit the Court shall dismiss the bill for want of jurisdiction, and the complainant shall appeal from such decision, such appeal may carry 122
up the whole case, both the question of jurisdiction and the merits, for the decision of the Appellate Court.

4. In taking evidence under the answer the defendant shall be at liberty to offer such evidence in support of the plea as it may deem material without taking such evidence directly under the plea separately and apart from the evidence taken on the merits under the answer.

5. Nothing in this stipulation contained shall be construed as an admission, in any respect, on the part of 123
either party hereto, in regard to any question of law raised by the plea herein or any question of fact raised by the issue joined on such plea.

6. Whereas, a large amount of testimony has already been taken under the plea herein, relating to Patents No. 227,229 and No. 265,777, of which the parties desire to have the benefit in the future, it is further stipulated that in case of any future controversy between the parties and their privies in relation to Patents No. 227,229 and No. 265,777, such testimony may be used 124
with the same force and effect as it might be used in this suit if the bill and the plea were not amended as above provided; and any question of costs by reason of past proceedings is reserved, without prejudice, for future adjustment between the parties.

In duplicate.

February 12, 1889.

RICHD. N. DYER,
Solicitor for Complainant.

DUNCAN, CURTIS & PAGE,
Solicitors for Defendant.

125 CIRCUIT COURT OF THE UNITED STATES.

SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY,
Complainant,

AGAINST

126 THE UNITED STATES ELECTRIC LIGHTING COMPANY,
Defendant.

} In Equity. No. 3445.

THE ANSWER OF THE UNITED STATES ELECTRIC LIGHTING COMPANY TO THE AMENDED BILL OF COMPLAINT EXHIBITED AGAINST IT BY THE COMPLAINANT, THE EDISON ELECTRIC LIGHT COMPANY.

127 And now comes the defendant herein, and saving and reserving to itself all and all manner of benefit and advantage of exception to the various errors, uncertainties and imperfections in the said bill of complaint contained, and especially not waiving the various matters and things set forth in the plea heretofore filed, but saving and reserving to itself the full benefit and advantage of the same, for answer to said bill, or to such parts thereof as this defendant is advised it is material
128 and necessary for it to make answer unto, answering, says:

1. This defendant admits that it is a corporation organized under the laws of the State of New York and having its principal place of business in the City of New York; also that the complainant, *The Edison Electric Light Company*, at the time of the filing of the bill herein, was a corporation organized under the laws of the said State, and having its principal place of business in said city.

2. This defendant admits that the Thomas Alva Edi- 129
son named in the bill of complaint made application for Letters Patent of the United States for an alleged improvement in electric lamps, on the 4th day of November, 1879, and that subsequently, but not until after various modifications had been made in the said application, Letters Patent of the United States were issued to him bearing date January 27, 1880, and numbered 223,898. But this defendant denies, in manner more explicitly hereinafter set forth, that the said Edison was the true, original and first inventor of the alleged im- 130
provement in electric lamps set forth in the said letters patent or to which the claims thereof relate; and that the said alleged improvement was not known or used in this country, and was not patented or described in a printed publication in this or any foreign country, before the said Edison's alleged invention or discovery thereof; and that it was not in public use or on sale in the United States for more than two years prior to his said application; and that the said Edison, in making the said application, complied with all the requirements 131
of the law in that behalf, and especially that he filed in the Patent Office a written description of his alleged improvement, of the character required by law; and that there was any due examination as to the novelty and utility of the said alleged improvement, as required by law; and that the said letters patent granted to or conferred upon the said Edison, his heirs and assigns, for the term of seventeen years from the date thereof, the exclusive right to make, use and vend the said alleged invention in the United States; and as to all 132
these matters this defendant leaves the complainant to make such proof as it may be advised.

3. As to the alleged assignment of February 12, 1880, whereby, as is set forth in the bill of complaint, the said Edison granted or conveyed to the complainant, *The Edison Electric Light Company*, the said Letters Patent No. 223,898, this defendant avers that it has no knowledge in regard thereto, and it therefore leaves the com-

133 plainant to make such proof in this regard as it may deem proper and material.

4. This defendant, further answering, denies the averment of the bill of complaint to the effect that the complainant is now the sole and exclusive owner of the said Letters Patent No. 223,898, and of all claims for infringment or violation thereof, and is entitled to sue for and receive said claims to its own use.

On the contrary, this defendant avers, on information
134 and belief, that, prior to the bringing of this suit and prior to the alleged acts of this defendant complained of in said bill as infringments of the said letters patent, the complainant, the said *The Edison Electric Light Company*, had granted, assigned and transferred to Thomas Alva Edison and to sundry corporations then existing, including *The Edison Company for Isolated Lighting, The United Edison Manufacturing Company, The Edison Machine Works, The Edison Tube Works*, and *Bergmann & Company*, corporations organized
135 under the laws of the State of New York, and *The Edison Lamp Company*, a corporation organized under the laws of the State of New Jersey, or to some of them, the sole and exclusive right to manufacture and to sell to others for use the alleged improvement in electric lamps described and claimed in said letters patent; and that by reason of the said grants, assignments and transfers the said *The Edison Electric Light Company*, if in fact it had ever been the sole and exclusive owner of the said letters patent, ceased to be the sole
136 and exclusive owner thereof, and at the commencement of this suit had not such an interest in the same as to enable it to maintain the suit in the manner and form in which the same has been brought.

And this defendant, in like manner, further avers that the complainant herein, *The Edison Electric Light Company*, subsequently to the bringing in of the bill of complaint, viz., on the 31st day of December, 1886, was consolidated with another corporation known as *Edison Company for Isolated Lighting*, and a new corporation was formed known as *Edison Electric Light*

Company: that by the said act of consolidation the complainant, *The Edison Electric Light Company*, was dissolved and its corporate existence terminated; that by reason thereof it then ceased to be the owner of any interest which previously it may have owned or possessed in the said letters patent, and of all claims for the alleged infringement or violation of the same, and became incapacitated to sue for or to receive said claims, whether to its own use or otherwise, or to prosecute the present suit; and that the suit itself then and thereby abated. 137

138

5. This defendant, further answering, denies that the alleged invention to which the said Letters Patent No. 223,898 relate is of any public utility, or that the making of the same by the said Edison has contributed in any measure whatever to the practical introduction of incandescent electric lighting; but, on the contrary, the somewhat extensive introduction of the incandescent electric lamp into public use which has taken place within the last few years has been, as this defendant 139
verily believes, the result wholly of other inventions than that disclosed by the patent in suit and covered by the claims thereof, and particularly of a certain invention, viz., a carbon for incandescent lamps made from fibrous or textile material, invented by William E. Sawyer and Albon Man, and for which Letters Patent of the United States have heretofore been granted to the assignees of the said Sawyer & Man, as well as of various other inventions which are owned and controlled by this defendant; and this practical introduc- 140
tion of the incandescent lamp has been due in large measure to the persistent efforts to that end which this defendant has made continually during the past ten years, by the use of the various inventions which it has owned and controlled, and at an expenditure of many hundreds of thousands of dollars.

And this defendant further denies that the public generally, in all or any parts of the United States, have recognized and acknowledged the validity of the said letters patent; and denies that the claims of the said

141 Edison and of the complainant and its licensees of the exclusive right to the said alleged invention have been generally acknowledged and acquiesced in.

On the contrary, this defendant, on information and belief, alleges the fact to be, that among those who are conversant with such matters, and whose opinion or judgment in the premises is of any value, the belief generally obtains that the alleged invention which the said letters patent profess to describe and claim is of no practical value or importance, and has in no wise
142 contributed to the development of the art; and that the said letters patent were granted inadvertently, without such examination as the law contemplates and requires, and are and always have been invalid, and particularly that the claims under which it is now sought to affect this defendant are utterly void and of no effect.

6. This defendant, further answering, denies that it has done any of the acts alleged in the bill of complaint and therein complained of as an infringement of
143 the said letters patent; and, more specifically, it denies the allegations of the bill of complaint that, contriving to injure the complainant, and deprive it of the benefit and advantage which might and otherwise would accrue to it from the said alleged invention, without the license of the complainant, against its will and protest, and in violation of its rights and of said letters patent, this defendant has made, sold and used, and caused to be made, sold and used, or is now making, selling and using, or causing to be made, sold and used, or intends
144 to continue to make, sell and use, and cause to be made, sold and used, incandescent electric lamps embodying and involving the alleged improvement covered by the said letters patent.

And this defendant further denies that any act or acts by it performed have resulted in any injury to the complainant as to any right secured to said complainant by the said letters patent; and defendant also denies that great or any gains and profits have accrued to it from the making, selling or using of any invention secured to the complainant by the said letters patent.

7. This defendant, further and specially answering, 145
upon information and belief, alleges that, before any invention or discovery by the said Edison of the alleged improvement in electric lamps to which it is claimed that the said Letters Patent No. 223,898 relate, the same, or substantial and material parts thereof, had been known to and invented by others, and had been used by others; and had also been patented and been described in printed publications—all as is more specifically set forth in the statements following:

A. The said alleged invention, or material and sub- 146
stantial parts thereof, had been invented by or were known to and were used by the following persons at the places named:

William E. Sawyer and Albon Man, who used the same in the City of New York, and whose use of it was known to Amos Broadnax, of Brooklyn, N. Y.; to William H. Church, Lawrence Myers and Jacob Hayes, of New York City; to Thomas 147
B. Stillman, of Hoboken, N. J.; to William Sawyer, now dead, and many others. The said William E. Sawyer is dead, but Albon Man resides in the City of Brooklyn.

Hiram S. Maxim, who resides in London, England, and who used the same in the City of New York, to the knowledge of many persons, stockholders and employees of the United States Electric Lighting Company.

Edward Weston, who resides in Newark, N. J., and 148
who used the same in the said City of Newark, to the knowledge of Edward Quimby, of Orange, N. J., and to various other persons.

Moses G. Farmer, who resides at Eliot, Maine, and who used the same at Newport, R. I., and at Boston, Mass.

B. The said alleged invention, or substantial and material parts thereof, had been patented and described in printed publications as follows:

149 *United States Letters Patent to—*

S. A. Kosloff, No. 166,877, August 17, 1875.

W. E. Sawyer & A. Man, { No. 205,144, June 18, 1878.
No. 210,809, Decem'r 10, 1878.
No. 211,262, January 7, 1879.

M. G. Farmer, No. 213,643, March 25, 1879.

Belgian Letters Patent to—

De Changy, 3244, August 28, 1856.

St. G. Lane Fox, 46,482, October 30, 1878.

French Letters Patent to—

150 George and Delalogue, No. 12,589, November 6, 1851.

A. N. Lodaguine, No. 97,583, of 1872.

......Khotinsky, No. 107,307, March 19, 1875.

S. W. Konn, No. 107,272, March 16, 1875.

......Bouliguine, No. 108,415, January 15, 1875.

Dobler & Stapfer, No. 127,498, Novem'r 16, 1878.

St. G. Lane Fox, No. 128,056, October 23, 1878.

Scotch Letters Patent to—

Edward A. King, on or about November 26, 1845.

151 *English or British Letters Patent to—*

Edward A. King, No. 10,919 of 1845.

W. Greener and W. E. Staite, No. 11,076 of 1846.

Wm. Staite, No. 12,212 of 1848.

E. C. Shepard, " 13,302 of 1850.

M. J. Roberts, " 14,189 of 1852.

S. W. Konn, " 3,809 of 1872.

S. W. Konn, " 91 of 1873.

S. A. Kosloff, No. 441 of 1875.

P. Jansen, " 970 of 1875.

152 E. G. Brewer, " 2,767 of 1875 (Provisional).

C. W. Harrison, " 3,470 of 1878.

St. G. Lane Fox, { No. 3,988 of 1878.
" 4,043 of 1878.
" 4,626 of 1878 (Provisional)
" 1,122 of 1879 (Provisional)

I. L. Pulvermacher, " 4,774 of 1878.

A. M. Thompson and H. D. Earl, No. 5,281 of 1878.

Printed publications as follows:

(1) The official publications printed and published by the United States of America, by

Belgium, by the Kingdom of Great Britain and 153
Ireland, and by France, containing the specifications of the various patents above named as existing prior to the date of the invention by Edison of the alleged improvement described and claimed in the patent in suit.

(2) Also the following:

The Mechanics' Magazine, Vol. 44, pp. 312–16 and 398; published in London in the year 1846.

The London, Edinburgh and Dublin Philosophical Magazine, third series, Vol. 27, pp. 154
442 *et seq.*; published in London in 1845.

Also same magazine, fifth series, Vol. 3, pp. 67 *et seq.*; published in London in the year 1877.

Proceedings of the Royal Society, Vol. 10, pp. 432 *et seq.*; published in London in the year 1860.

Also same publication for the year 1875, Vol. 23, pp. 356 *et seq.*

Also same publication for the year 1878, Vol. 27, pp. 29–38.
155

Annalen Der Physik und Chimie, pp. 1 *et seq.*; published in Germany by Poggendorf in the year 1869.

Year Book of Facts, by Chas. W. Vincent, p. 138; published in London in the year 1874 by Ward, Lock & Tyler.

Les Mondes, Vol. 1, pp. 183 *et seq.*; published in Paris in the year 1875.

The Chemical News and Journal of Physical Science, Vol. 36, pp. 13 *et seq.*; published in 156
London July 6, 1877.

Same journal, Vol. 39, pp. 168 *et seq.*; published in London in the year 1879.

The Scientific American, Vol. 39, p. 351; published in the City of New York, by Munn & Co., in the year 1878.

Same journal, Vol. 40, p. 40; published in New York, January 18, 1879.

Engineering, p. 293; published in London by Maw & Dredge, in the year 1878.

157 Transactions of the Newcastle-upon-Tyne Chemical Society, Vol. 4, pp. 190 *et seq.;* published at Newcastle-upon-Tyne, England, in the year 1878.

The Monthly Journal of Science, third series, Vol. 1, pp. 155 *et seq.*, and pp. 168 *et seq.;* published in London, in February of the year 1879.

The American Journal of Science and Art, third series, Vol. 18, pp. 241-262; published in
158 New Haven, in the year 1879, by J. T. & E. S. Dana.

Philosophical Transactions of the Royal Society of London, published in London, as follows:

Vol. 164, Part II., pp. 501-528; published in the year 1874.

Vol. 165, Part II., pp. 519-547; published in the year 1876.

Vol. 166, Part II., pp. 325-376; published in
159 the year 1877.

Vol. 169, Part I., pp. 155-238, 243-318; published in the year 1878.

Vol. , Part I., pp. 49 *et seq.;* published in the year 1849.

Vol. , Part I., pp. 87-164; published in the year 1879.

Journal of the Society of Arts, Vol. 21, p. 779; published in London in the years 1872-3.

160 8. This defendant, further and specially answering, avers, on information and belief, that in view of the state of the art of electric lighting and of the connected or allied arts, as they existed prior to the date of the supposed invention or discovery by the said Thomas Alva Edison of the alleged invention or improvement to which the said Letters Patent No. 223,898 relate, and particularly of the inventions disclosed in the various patents and publications in this answer named, the said invention or improvement did not constitute a new and useful art, machine, manufacture or composition of matter, or any new and useful improvement thereof,

within the meaning and intent of the statutes of the 161
United States relating to the grant of patents for inventions and discoveries; that the things and combinations respectively specified and recited in the several claims of the said letters patent as constituting the alleged invention thereby attempted to be patented do not exhibit or embody any substantial variation or change from what had belonged to the art as it existed at the date of said Edison's assumed invention, and did not involve the exercise of the inventive faculty
nor constitute patentable invention, nor form the 162
proper subject of letters patent, but were matters within the domain of common knowledge among persons then skilled in the art; and for this reason also this defendant avers, and will maintain, that said Letters Patent No. 223,898 were and are invalid and cannot be enforced.

9. This defendant, further and specially answering, avers, on information and belief, that the said Thomas
Alva Edison surreptitiously and unjustly obtained the 163
said Letters Patent No. 223,898 for that which was in fact invented by others, viz.: by William E. Sawyer and Albon Man, then residing in the City of New York, who were using reasonable diligence in adapting and perfecting the same.

10. This defendant, further answering, avers that if, in fact, the said Edison had made any practically useful invention pertaining to incandescent electric lamps
or to the art of incandescent electric lighting prior to 164
his application for the Letters Patent No. 223,898, to which this suit relates, he failed to file in the Patent Office in connection with his said application, as required by law as a condition precedent to the grant of a valid patent, a written description of the manner and process of making, constructing and using the invention in such full, clear, concise and exact terms as to enable a person skilled in the art or science of electric lighting or the connected arts to make, construct and use the same; and this defendant avers that the specification

165 which is annexed to the said letters patent is not such a description as the law requires, and that the said patent, therefore, is null and void.

11. And this defendant, further answering, avers on information and belief, that for the purpose of deceiving the public the description and specification filed by the said Edison in the Patent Office, in connection with his said application, was made to contain less than the whole truth relative to his invention or discovery; and
166 also that, for the same purpose, the claims of the said letters patent were so drawn as to cover more than any invention or discovery that the said Edison had then made.

12. This defendant, further answering, on information and belief, alleges that before the grant to the said Edison of the Letters Patent No. 223,898, on which the bill herein is brought, the invention to which the said letters patent relate had been patented by the said
167 Edison, or with his consent and procurement, in various foreign countries, viz., in the Dominion of Canada, on the 17th day of November, 1879, by Letters Patent No. 10,654, granted for the term of five years; in the Kingdom of Great Britain and Ireland, by Letters Patent No. 4576, bearing date the 10th day of November, 1879, and granted for the term of fourteen years; in the Republic of France, by Letters Patent No. 133,756, bearing date the 20th day of January, 1880, and granted for the term of fifteen years; in Belgium, by Letters
168 Patent No. 49,884, dated November 29, 1879, and in the Kingdom of Italy, by letters patent bearing date the 6th day of December, 1879, and issued for the term of six years from the 31st day of December, 1879, and this defendant avers and will maintain that by reason of the premises the Commissioner of Patents of the United States had no power under the law to issue a patent on the said invention for the term of seventeen years, and that if the said Letters Patent No. 223,898 on which the bill herein is brought were issued for the term of seventeen years, as is alleged in the bill of com-

plaint, they were so issued without authority of law, 169
and were and are null and void *ab initio*.

If, however, contrary to the allegations of the bill of complaint, the said letters patent were not granted for the term of seventeen years, then this defendant avers and will maintain that they were so limited by operation of law as to expire either at the same time with the actual expiration of that one of the various prior foreign patents for the same invention which for any cause was the first to expire or lose its force—that is,
on or before the 17th day of November, 1881, as is 170
more fully hereinafter set forth, or, if not with the actual expiration of such prior foreign patent, with the expiration of the shortest term of any of the aforesaid foreign patents, current at the date of the issue of the said U. S. Letters Patent No. 223,898—that is, at the end of five years from the 17th day of November, 1879, this being the date of the aforesaid Canadian patent, which, as above set forth, was granted for the term of five years, which term, as this defendant is informed
and believes, was the shortest term of any of the afore- 171
said prior foreign patents.

And this defendant, on information and belief, further avers that the aforesaid Canadian patent granted to the said Edison on the 17th day of November, 1879, for the term of five years as aforesaid, was granted subject to the condition expressed on the face of the patent itself that the patent and all the rights and privileges thereby granted should cease and determine, and that the patent should be null and void at the end of two
years from the date thereof unless the patentee, his 172
executors, administrators or his assignee or assignees should within that period have commenced, and after such commencement should continuously carry on in Canada the construction or manufacture of the invention thereby patented, in such manner that any person desiring to use it might obtain it, or cause it to be made for him, at a reasonable price, at some manufactory or establishment for making or constructing it in Canada, and subject, also, to the further condition, expressed on the face of the said patent, that the patent should be

173 void if, after the expiration of twelve months from the granting thereof, the patentee, his executors or administrators, or his assignee or assignees, for the whole or a part of his interest in the patent, should import or cause to be imported into Canada the invention for which the patent was granted; that by the Patent Act of Canada it was competent for the Commissioner of Patents, upon due application made, to extend the times thus limited for the importation and for the manufacture of the patented invention, and that, by
174 virtue of this power, the Commissioner did extend to the owners of the said Edison patent the time for manufacturing, for a further period of three months but not longer, but that the time within which the invention might be imported was never extended; that by the statutes of the Dominion of Canada original and final jurisdiction, in Canada, over the question whether the said patent has at any time become null and void, under either of the conditions above set forth, is given to the Minister of Agriculture or his deputy;
175 that on or about the 1st day of May, 1888, *The Royal Electric Company of Canada* filed a petition with the Minister of Agriculture of the said Dominion of Canada, praying to have the said patent adjudged null and void on the grounds both that the owners of the said patent had imported the patented invention, in violation of the above condition in regard to the importation of the same, and also had failed to begin and continue the manufacture of the invention within the Dominion of Canada as required by the above condition relating
176 thereto; that the *Edison Electric Light Company*, a corporation organized under the laws of the State of New York, and the owner of the said Canadian patent, having derived title thereto from *The Edison Electric Light Company*, the complainant herein, was made the respondent to said petition; that the parties to the said petition, both the petitioner and the respondent, appeared before the Deputy Commissioner of Patents, who was also the deputy of the Minister of Agriculture, and by due form of proceedings produced before the said tribunal the facts upon

which they respectively relied, and afterwards argued 177
the case at great length before the said deputy of the said Minister; and that subsequently, and after due and careful consideration, had, viz., on or about the 26th day of February, 1889, the said deputy of the Minister of Agriculture rendered his decision in the premises, in which he found, among other things, that the owners of the aforesaid Canadian patent had not at any time since the date thereof manufactured the patented invention in Canada, and also that they had, after the expiration of twelve months from the granting of the said patent, 178
and on or prior to November 17, 1881, imported the invention into Canada, for which reasons he adjudged that the said patent had become null and void; which decision was a judgment by the said tribunal that the said Canadian patent became null and void, and ceased and determined, or expired and lost its force, at a date not later than November 17, 1881. And this defendant in like manner avers that the aforesaid findings of the Canadian Commissioner of Patents were in accordance with the actual facts in the case, and that 179
in fact the said owners of the said Canadian patent, contrary to the above-named condition expressed in the patent, not having obtained an extension of the time named in the patent for the importation of the invention, did import the patented invention into Canada after the expiration of twelve months from the granting of the patent, and on or prior to November 17, 1881; and, also, contrary to the further condition in said patent expressed as above set forth, did neglect and fail for the period of two years and three months from the 180
date of said patent to commence the manufacture of the patented invention in Canada, and, in fact, have not commenced such manufacture down to the present time. For which reasons this defendant avers and will maintain that the said United States Letters Patent, No. 223,898, instead of being granted for a term of seventeen years as set forth in the bill of complaint, were either so limited as to expire, and did in fact expire, on or before the 17th day of November, 1881, when the said Canadian patent became null and void and lost its force, or was so lim-

181 ited as to expire, and did in fact expire, with the term of five years for which the aforesaid Canadian patent was granted, viz., on the 17th day of November, 1884. In either case the said United States Patent was not granted for a term of seventeen years; and in either case, this defendant alleges and will contend that the said patent had expired before the bill herein was brought, and that by reason thereof this Court has no jurisdiction in equity over the alleged cause of action and ought not to take cognizance of or entertain this
182 suit, since the complainant, if it has any lawful demand against the defendant, has a plain, adequate and complete remedy at law, or that, if the Court can hold the bill, it is without power to grant an injunction against the defendant, as prayed in the bill.

13. This defendant, further answering, says, on information and belief, that after the issue of the said Letters Patent No. 223,898 on which the bill herein is brought, viz., on or about November 19, 1883, and
183 before the filing of the bill herein, *The Edison Electric Light Company*, the complainant herein, being at the time the assignee of record of the said patent, tendered the same to the Commissioner of Patents, accompanied with a petition setting forth that prior to the grant of the same the patentee had taken foreign patents on the same invention in Great Britain and Ireland, in Belgium, in France, in Italy and in Canada—the patent in the latter country being dated November 17, 1879, and numbered 10,654; that in consequence of the omission
184 of the said Edison to make such facts known to the Commissioner of Patents, the said patent had been granted "unlimited, for the full term of seventeen years," that the said company was then advised that "the said letters patent, when issued, should have been limited on their face to the term of the foreign patent having the shortest term, dated prior to the date of the United States Patent;" and that on the 18th day of December, 1883, in compliance with the said petition of the complainant, the Commissioner of Patents and the Secretary of the Department of the Interior, by

virtue of the power in them vested by the statutes 185
relating thereto, made the following endorsement on the said letters patent:

"DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., December 18, 1883.

"In compliance with the request of the party in interest, Letters Patent No. 223,898, granted
January 27, 1880, to Thomas A. Edison, of Menlo 186
Park, New Jersey, for an improvement in 'Electric Lamps,' is hereby limited so as to expire at the same time with the patent of the following named having the shortest time to run, viz., British Patent, dated November 10, 1879, No. 4576; Canadian Patent, dated November 17, 1879, No. 10,654; Belgian Patent, dated November 29, 1879, No. 49,884; Italian Patent, dated December 6, 1879; and French Patent, dated January 20, 1880, No.
133,756. 187

"It is hereby certified that the proper entries and corrections have been made in the files and records of the Patent Office.

"This amendment is made that the United States Patent may conform to the provisions of Section 4887 of the Revised Statutes.

BENJAMIN BUTTERWORTH,
Commissioner of Patents."

"Approved, 188
M. L. JOSLYN,
Acting Secretary of the Interior."

And this defendant alleges and will contend that by virtue of the premises the complainant is estopped from now asserting that the patent which was thus amended, being the patent on which the bill herein is brought, is a patent having a term of seventeen years, as is alleged in the bill of complaint; and that by virtue of the premises, independently of all other considerations, the

189 said letters patent expired not later than the expiration of the term of the said Canadian patent, current at the date of the issue of the said U. S. patent, viz., not later than November 17, 1884, even if they did not expire, as this defendant will contend, on or prior to the 17th day of November, 1881, at which last-named date, according to the judgment, as above set forth, of the tribunal having jurisdiction of the question, the said Canadian patent had become null and void.

190 14. And this defendant, further answering, says that, as to the various averments in the bill of complaint contained in regard to the circumstances under which the alleged invention was made which forms the subject of the letters patent in suit, and under which a patent for the same was obtained in the Dominion of Canada, it has no knowledge in relation to the matter other than that hereinbefore set forth and that derived from the bill of complaint, and defendant therefore denies all the averments of the bill in that behalf, save as they
191 have been hereinbefore admitted, and leaves the complainant to make such proofs in the premises as it may be advised to be necessary or proper.

And now this defendant, having fully answered all and singular those parts of the bill of complaint which it is material and necessary for it to answer, prays the same benefit of the several matters and things hereinbefore alleged and set forth as if by reason thereof it had demurred or had pleaded to the said bill; and it
192 prays to be hence dismissed with its reasonable costs and charges herein most wrongfully sustained.

THE UNITED STATES ELECTRIC LIGHTING COMPANY,
By DUNCAN, CURTIS & PAGE,
Solicitors.

S. A. DUNCAN,
L. E. CURTIS,
J. B. KERR,
E. WETMORE,
Of Counsel.

STATE OF NEW YORK,
City and County of New York, } ss.: 193

GEORGE W. HEBARD, being duly sworn, deposes and says that he is president of the United States Electric Lighting Company, the defendant in the suit above named; that he has read the foregoing answer and knows the contents thereof, and that the same is true of his own knowlege, except as to the matters and things therein alleged to be stated on information and belief, and as to all those he believes it to be true.

GEORGE W. HEBARD. 194

Sworn to before me this 1st day of April, 1889. }

ROBT. F. GAYLORD,
[L. S.] Notary Public (8),
N. Y. Co.

CIRCUIT COURT OF THE UNITED STATES, 195

SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY,
Complainant,

AGAINST

THE UNITED STATES ELECTRIC LIGHTING COMPANY,
Defendant,

In Equity. No. 3445. 196

And now comes the defendant herein, and by leave of Court first had and obtained, amends its plea, heretofore filed and now pending, as follows:

This defendant avers, on information and belief, that the Canadian patent referred to in the said plea (being

197 the patent No. 10,654 granted to Thomas Alva Edison,
in the Dominion of Canada, on November 17, 1879, for
a term of five years, for the same alleged invention
which is described and claimed in the patent here in
suit), was granted subject to the condition, expressed on
its face, that the patent and all the rights and privileges
thereby granted should cease and determine, and that
the patent should be null and void at the end of
two years from the date thereof, unless the patentee,
his executors, administrators or his assignee or as-
198 signees, should within that period have commenced,
and after such commencement should continuously
carry on in Canada the construction or manufacture
of the invention thereby patented, in such manner
that any person desiring to use it might ob-
tain it, or cause it to be made for him at a rea-
sonable price, at some manufactory or establishment
for making or constructing it in Canada, and sub-
ject, also, to the condition, expressed on the face of the
said patent, that the patent should be void if, after the
199 expiration of twelve months from the granting thereof,
the patentee, his executors or administrators, or his
assignee or assignees, for the whole or a part of his in-
terest in the patent, should import, or cause to be im-
ported, into Canada the invention for which the patent
was granted; that by the Patent Act of Canada it was
competent for the Commissioner of Patents, upon due
application made, to extend the time thus limited for
the importation and for the manufacture of the patented
invention, and that, by virtue of this power, the Com-
200 missioner did extend to the owners of the said Edison
patent the time for manufacturing for a further period
of three months, but not longer, but that the time
within which the invention might be imported was
never extended; that by the statutes of the Dominion
of Canada original and final jurisdiction, in Canada,
over the question whether the said patent has at
any time become null and void, under either of
the conditions above set forth, is given to the
Minister of Agriculture or his deputy; that on or
about the first day of May, 1888, *The Royal Electric*

Company of Canada filed a petition with the Min- 201
ister of Agriculture of the said Dominion of Canada
praying to have the said patent adjudged null and void
on the grounds both that the owners of the said patent
had imported the patented invention in violation of the
above condition in regard to the importation of the
same, and also had failed to begin and continue the
manufacture of the invention within the Dominion of
Canada as required by the above condition relating
thereto; that the *Edison Electric Light Company*, a
corporation organized under the laws of the State of 202
New York, and the owner of the said Canadian patent,
having derived title thereto from *The Edison Electric
Light Company*, the complainant herein, was made the
respondent to said petition; that the parties to the
said petition, both the petitioner and the respondent,
appeared before the Deputy Commissioner of Patents,
who was also the deputy of the Minister of Agriculture,
and by due form of proceedings produced before
the said tribunal the facts upon which they respect-
ively relied, and afterwards argued the case at great 203
length before the said deputy of the said Minister; and
that subsequently, and after due and careful considera-
tion had, viz., on or about the 26th day of February,
1889, the said deputy of the Minister of Agriculture
rendered his decision in the premises, in which he
found, among other things, that the owners of the
aforesaid Canadian patent had not at any time since
the date thereof manufactured the patented invention
in Canada, and also that they had, after the expiration
of twelve months from the granting of the said patent, 204
and on or prior to November 17, 1881, imported the
invention into Canada, for which reasons he adjudged
that the said patent had become null and void; which
decision was a judgment by the said tribunal that the
said Canadian patent became null and void, and ceased
and determined, or expired and lost its force, at a date
not later than November 17, 1881. And this defend-
ant, in like manner, avers that the aforesaid findings of
the Canadian Commissioner of Patents were in accord-
ance with the actual facts in the case, and that in fact

205 the said owners of the said Canadian patent, contrary to the above-named condition expressed in the patent, not having obtained an extension of the time named in the patent for the importation of the invention, did import the patented invention into Canada after the expiration of twelve months from the granting of the patent, and on or prior to November 17, 1881; and also, contrary to the further condition in said patent expressed, as above set forth, did neglect and fail for the period of two years and three months from the date of
206 said patent to commence the manufacture of the patented invention in Canada, and in fact have not commenced such manufacture down to the present time.

For which reasons this defendant avers and will maintain that the said United States Letters Patent, No. 223,898, were not granted for a term of seventeen years, as set forth in the bill of complaint, and, if not so limited as to expire with the term of five years for which the aforesaid Canadian patent nominally was granted, as is set up in the plea to which this is an
207 amendment, were so limited as to expire, and did in fact expire, on or before the 17th day of November, 1881, when according to the aforesaid judgment, the said Canadian patent became null and void and lost its force. And this defendant is informed and believes that the complainant herein may contend that such effect does not follow from the aforesaid decision of the Canadian Commissioner of Patents, or from the various facts above alleged, inasmuch as, subsequently to the said acts and defaults upon which the said Commissioner
208 found that the Canadian patent had become null and void, the said patent was extended by the Commissioner of Patents for a further and second term of five years, and thereafter for a further and third term of five years; but this defendant alleges and will contend that such extensions, if granted (which this defendant denies), were themselves nullities and of no effect, since the patent had previously expired, as above set forth, so that there was no right or power on the part of the said Commissioner to grant or make any extension whatever.

In view of the premises, the defendant alleges and will contend that the United States patent had expired before the bill herein was brought; and this defendant avers that, by reason thereof, this Court has no jurisdiction in equity over the alleged cause of action, and ought not to take cognizance of or entertain this suit, since the complainant, if it has any lawful demand against the defendant, has a plain, adequate and complete remedy at law. 209

All which matters and things this defendant doth aver to be true, and doth plead the said expiration of the said Letters Patent No. 223,898 to the jurisdiction of the Court, and prays the judgment of this Court whether it ought to be required to make any other or further answer to the said amended bill, and prays to be hence dismissed with its costs and charges in that behalf most wrongfully sustained. 210

THE UNITED STATES ELECTRIC LIGHTING CO.,
By DUNCAN, CURTIS & PAGE,
Solicitors of Defendant.

SAML. A. DUNCAN,
EDMUND WETMORE, 211
Of Counsel.

STATE OF NEW YORK, }
City and County of New York, } ss.:

LEONARD E. CURTIS, being duly sworn, deposes and says that he is the Secretary of the corporation defendant in the above-entitled suit, and that the foregoing plea is not interposed for the purposes of delay, and that the same is true in point of fact. 212

LEONARD E. CURTIS.

Sworn to before me this 20th }
day of April, 1889. }

ROBT. F. GAYLORD,
[SEAL.] Notary Public (8),
N. Y. Co.

The undersigned, of counsel for the defendant in the

213 above-entitled suit, hereby certify that in their opinion the foregoing plea is well founded in point of law.

SAML. A. DUNCAN,
EDMUND WETMORE.

CIRCUIT COURT OF THE UNITED STATES,

SOUTHERN DISTRICT OF NEW YORK.

214

THE EDISON ELECTRIC LIGHT COMPANY
vs.
THE UNITED STATES ELECTRIC LIGHTING COMPANY.
} In Equity.

215 The replication of The Edison Electric Light Company, complainant, to the answer of The United States Electric Lighting Company, defendant.

This repliant, saving and reserving unto itself now and at all times hereafter, all and all manner of benefit and advantage of exception which may be had or taken to the manifold insufficiencies of the said answer, for replication thereunto says that it will aver, maintain and prove its said bill of complaint to be true, certain and sufficient in law to be answered unto, and that the

216 said answer of the said defendant is uncertain, untrue and insufficient to be replied unto by this repliant. Without this that any other matter or thing whatsoever in the said answer contained, material or effectual in the law to be replied unto, and not herein and hereby well and sufficiently replied unto, confessed or avoided, traversed or denied, is true. All which matters and things this repliant is and will be ready to aver, maintain and prove as this Honorable Court shall direct, and humbly prays as in and by its said bill it has already prayed.

R. N. DYER,
Complainant's Solicitor.

217

UNITED STATES CIRCUIT COURT,

SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY
vs.
THE UNITED STATES ELECTRIC LIGHTING COMPANY.
} In Equity. No. 3445. 218

And now, to wit, September 27, 1889, in order to obviate the necessity of an application to the Court for an order to apportion the time for taking testimony herein, pursuant to the provisions of Equity Rule 67, as amended, as has been proposed by complainant's counsel, it is hereby stipulated that the time be apportioned 219
as follows:

Complainant to have until November 1, 1889, to take its proofs in support of its bill; defendant to have until January 1, 1890, to take its proofs, and the complainant to have until February 1, 1890, to take its proofs in reply.

Either party shall be at liberty to put the cause on the calendar for final hearing at the coming February Term, such hearing, however, to be had, subject to the convenience and rules of the Court, at a time not less 220
than twenty days after the completion of the proofs.

This stipulation is made without prejudice to the right of either party to apply to the Court for an enlargement of time under the rules.

September 27, 1889.

RICHD. N. DYER,
Solicitor for Complainant.
DUNCAN, CURTIS & PAGE,
Solicitors for Defendant.

221 CIRCUIT COURT OF THE UNITED STATES,

SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY,
Complainant,

vs.

222 THE UNITED STATES ELECTRIC LIGHTING COMPANY,
Defendant.

In Equity.
No. 3445.

Notice is hereby given that we shall proceed to take proofs for final hearing on the part of the complainant under the Sixty-seventh Rule of the Supreme Court
223 for Courts in Equity, as amended or in accordance with the statutes in such case, made and provided, and in pursuance of the rules and practice of this Court, before an Examiner of this Court, or other proper officer under said statutes and rules, at my office, No. 40 Wall street, New York City, on the 15th day of October, 1889, at eleven o'clock in the forenoon.

You are invited to attend and cross-examine any witnesses produced. The examination will be adjourned from day to day and to such time and place as may be required without further notice.

224 Dated New York, October 9th, 1889.

RICHD. N. DYER,
Complainant's Solicitor,
40 Wall Street,
New York City, N. Y.

To MESSRS. DUNCAN, CURTIS & PAGE,
Defendant's Solicitors,
120 Broadway, N. Y.

Service acknowledged this 9th day of October, 1889.
SAML. A. DUNCAN.

225

CIRCUIT COURT OF THE UNITED STATES,

SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY,
Complainant, 226

AGAINST

THE UNITED STATES ELECTRIC LIGHTING COMPANY,
Defendant.

In Equity. No. 3445.
On Letters Patent No. 223,898.

Testimony taken on behalf of the complainant pursuant to the Sixty-seventh Rule in Equity as amended, before SAMUEL M. HITCHCOCK, one of the Standing Examiners of the said Court. 227

NEW YORK, October 15th, 1889.

Met pursuant to notice.

Present—C. A. SEWARD, S. B. EATON and R. N. DYER, ESQS., for complainant; and THOMAS B. KERR, ESQ., for defendant. 228

Counsel for complainant offer in evidence a certified copy of Letters Patent of the United States, No. 223,-898, granted January 27, 1880, to Thomas A. Edison, for improvement in electric lamps, the same being the patent in suit, and the same is marked "Complainant's Exhibit Patent in Suit."

Counsel for complainant also offer in evidence a

229 certified copy of an instrument in writing executed by Thomas A. Edison, February 12, 1880, and recorded in the Patent Office, the same including an assignment of the entire right, title and interest in and to the patent in suit to the complainant, and the same is marked "Complainant's Exhibit Assignment from Edison to Complainant."

Counsel for complainant also offer in evidence a certified copy of the certificate of incorporation of the complainant company, and the same is marked "Com-
230 plainant's Exhibit Certificate of Incorporation of the Edison Electric Light Company."

Counsel for defendant, at the request of counsel for complainant, and in order to facilitate the taking of complainant's *prima facie* proofs, admits, that after the grant of the patent in suit herein and before the filing of the bill of complaint, defendant manufactured, sold and used the following described incandescent electric lamps:

231 1. The incandescent electric lamp hereby tendered by counsel for the defendant to counsel for the complainant, which is provided with an incandescent carbon conductor having a zig-zag form. The incandescent conductor of the said lamp is made by the carbonization of paper. The zig-zag form of the conductor is given it by cutting the same from a sheet of paper by means of suitable dies prior to carbonization. The dimensions of the carbon in the said zig-zag lamp are as follows: Length, 6.16
232 inches; width, .012 inches; thickness, .004875 inches. That the resistance of said carbon, measured cold, is 158.2 ohms, and that the lamp is designed to give a light of 16 candles when placed upon a circuit having an electro-motive force of 70 volts.

2. An incandescent electric lamp similar in appearance in all respects to the zig-zag lamp already referred to, but having the incandescent conductor made from tamidine by punching from a sheet of tamidine prior to carbonization, the zig-zag form of the carbon with the

same dies used for punching out the paper for zig-zag 233
paper carbon. The dimensions of the carbon of the tamidine lamp are as follows: Length, 6.16 inches; width, .012 inches; thickness, .0025 inches. The resistance of the carbon of the tamidine lamp is about double that of the paper zig-zag lamp before referred to, and the tamidine lamp is designed to give a light of 16 candles when placed upon a circuit having an electro-motive force of 110 volts.

3. The incandescent electric lamp now tendered by 234
counsel for defendant to counsel for complainant, and having an incandescent carbon conductor in the general form of the letter M. The carbon of the said lamp is produced by stamping with dies the M-shaped form from a sheet of paper, after which the form is carbonized. The dimensions of the carbon of said lamp are as follows: Length, 4.25 inches; width, .024 inches; thickness, .0055 inches. The resistance of said carbon measured cold is 78.9 ohms, and the said lamp is designed to give a light equal to 16 candles when con- 235
nected with a circuit having an electro-motive force of 60 volts.

It is also admitted by counsel for defendant with respect to each of the above three lamps that the air was exhausted from each lamp globe before the same was sealed.

Counsel for complainant offer in evidence the zig-zag lamp first tendered by counsel for defendant, and the same is marked "Complainant's Exhibit Defendant's Zig-Zag Lamp, October 15, 1889." 236

Counsel for complainant also offer in evidence the second lamp tendered by counsel for defendant, and the same is marked "Complainant's Exhibit Defendant's M-Lamp, October 15, 1889."

Adjourned to meet at the same place, Saturday, October 19th, 1889, at 11 o'clock A. M.

237 New York, October 19th, 1889.

Met pursuant to adjournment.

Present—C. A. Seward, S. B. Eaton and R. N. Dyer, Esqs., for complainant, and General S. A. Duncan and Thomas B. Kerr, for defendant.

George F. Barker, being called on behalf of complainant, and duly affirmed, testified as follows in
238 answer to questions by Mr. Dyer:

1 Q. What is your name, age, residence and occupation?

A. George F. Barker; 54 years of age. I reside at Philadelphia, Pa. I am Professor of Physics in the University of Pennsylvania.

2 Q. What opportunities have you had for becoming acquainted theoretically and practically with the application of electricity to the useful arts, and espe-
239 cially to electric lighting, and what experience have you had in the consideration of patents for inventions on this subject?

A. Before entering Yale College I spent several years in the practical construction of physical (including electrical) apparatus. I have been professor of chemistry and physics pretty nearly thirty years; have paid particular attention during this time to the subject of electricity, not only for the purpose of teaching the same in my classes, but also for the purpose of my own
240 investigations. I have always had an extended collection of apparatus at my disposal for the purpose of experiment.

I am a member of the National Academy of Sciences, of the American Association for the Advancement of Science (of which I have been the president), of the Institute of Electrical Engineers of London and the Societé Internationale des Electriciens of Paris. I acted as one of the U. S. Commissioners to the International Electrical Exhibition at Paris, in 1881; was a vice-

president of the jury of award and chairman of the sub- 241
commission of the jury appointed to report on incandescent lamps. I was also one of the delegates representing the United States in the International Congress of Electricians held at the same time in Paris; and I received from the French Government the decoration of Commander of the Legion of Honor. In 1884 I was appointed by President Arthur a member of the U. S. Electrical Commission.

During the past twenty years or more I have been frequently called upon to testify as an expert in patent 242
causes, especially those involving electrical questions particularly with reference to electric lighting.

3 Q. Have you examined and do you understand the patent in suit?

A. I have examined the said patent and believe that I understand it.

4 Q. I call your attention to "Complainant's Exhibit Defendant's Zig-Zag Lamp;" and to "Complainant's Exhibit Defendant's M-Lamp"; also to the admission made upon the record October 15th, 1889, by 243
defendant's counsel with respect to the construction of these two exhibit lamps and also with respect to the construction of defendant's tamidine lamp. Do you understand the construction of these lamps?

A. I do. The admission of defendant's counsel, referred to in the question, affords all the required information not to be obtained from the lamps themselves put in as exhibits.

5 Q. Please compare the defendant's lamps, viz.: "Complainant's Exhibit Defendant's Zig-Zag Lamp," 244
"Complainant's Exhibit Defendant's M-Lamp," and defendant's tamidine lamp, with the patent in suit, and state whether or not, in your opinion, the said lamps of the defendant embody in their construction the invention of the patent in suit as recited in any of the claims thereof, giving your reasons for the opinion which you may express?

A. I would like to say that this answer being a matter of importance, requiring accuracy and precision of

245 statement, I have prepared it in advance and will proceed to read it as thus prepared.

Adjourned by consent to meet at "The Stratford," Philadelphia, at 2 o'clock P. M., Monday, October 21st, 1889.

"The Stratford," Philadelphia,
246 Monday, Oct. 21st, 1889.

Met pursuant to adjournment.

Present—C. A. Seward and R. N. Dyer, Esqs., for Complainant; and Samuel A. Duncan, Esq.. for Defendant.

The witness, Prof. Barker, being in attendance, continued his answer to the 5th question as follows:

247 A. The preamble of the specification of the patent gives the title of the invention as an "Improvement in electric lamps and the method of manufacturing the same." This is followed by the statement that

"The object of this invention is to produce electric "lamps giving light by incandescence, which lamps "shall have high resistance, so as to allow of the prac- "tical subdivision of the electric light."

The class of electric lamps referred to is that in which the light is produced by the heating of a continuous
248 conducting strip introduced into an electric circuit. The strip which constitutes the burner offering a greater resistance to the passage of the electric current than the metallic wires leading to it, the burner becomes heated to a white heat or light-giving incandescence by the energy which the current expends in forcing its way through it. Lamps of this kind are known as incandescent lamps. They are to be. distinguished from arc lamps in which are employed two rods of carbon with their ends brought close together but not touching. In this class of lamps the electric cur-

rent in overcoming the resistance to its passage 249
offered by the air space between the two ends of the carbon rods, heats the adjacent surfaces from which the light is emitted. A third class of electric lamps, which at one time seemed likely to become practically useful, are those in which the pointed end of a small carbon rod rests against a block of carbon. The imperfect contact produces an arc action similar to that in the arc lamp. For want of a better name these lamps are known as "arc-incandescent" or "semi-incandescent" lamps.

The distinguishing difference between the incandes- 250
cent lamps and the lamps of the other two classes is that in the former the resistance which is productive of the light-giving heat resides in the conductor itself, while in the latter it is an air space or an imperfect contact which offers the resistance.

The patent in suit before describing the construction which constitutes the invention refers to the prior lamps in the following language:

"Heretofore light by incandescence has been ob- 251
"tained from rods of carbon of one to four ohms "resistance, placed in closed vessels, in which the "atmospheric air has been replaced by gases that do "not combine chemically with the carbon. The vessel "holding the burner has been composed of glass ce- "mented to a metallic base. The connection between "the leading wires and the carbon has been obtained "by clamping the carbon to the metal. The leading- "wires have always been large, so that their resistance "shall be many times less than the burner, and, in 252
"general, the attempts of previous persons have been "to reduce the resistance of the carbon rod."

These old lamps were not commercially successful. The reasons are stated by the patent as follows:

"The disadvantages of following this practice are, "that a lamp having but one to four ohms resistance "cannot be worked in great numbers in multiple arc "without the employment of main conductors of enor- "mous dimensions; that, owing to the low resistance "of the lamp, the leading-wires must be of large

253 "dimensions and good conductors, and a glass globe "cannot be kept tight at the place where the wires "pass in and are cemented; hence the carbon is con- "sumed, because there must be almost a perfect "vacuum to render the carbon stable, especially when "such carbon is small in mass and high in electrical "resistance.

"The use of a gas in the receiver at the atmospheric "pressure, although not attacking the carbon, serves to "destroy it in time by 'air-washing,' or the attrition
254 "produced by the rapid passage of the air over the "slightly-coherent highly-heated surface of the carbon."

The specification of the patent in suit then continues:

"I have reversed this practice. I have discovered "that even a cotton thread properly carbonized and "placed in a sealed glass bulb exhausted to one-mil- "lionth of an atmosphere offers from one hundred to "five hundred ohms resistance to the passage of the "current, and that it is absolutely stable at very high
255 "temperatures; that if the thread be coiled as a spiral "and carbonized, or if any fibrous vegetable substance "which will leave a carbon residue after heating in a "closed chamber be so coiled, as much as two thousand "ohms resistance may be obtained without presenting "a radiating surface greater than three-sixteenths of "an inch; that if such fibrous material be rubbed with "a plastic composed of lampblack and tar, its resist- "ance may be made high or low, according to the "amount of lampblack placed upon it; that carbon
256 "filaments may be made by a combination of tar and "lampblack, the latter being previously ignited in a "closed crucible for several hours and afterwards moist- "ened and kneaded until it assumes the consistency of "thick putty. Small pieces of this material may be "rolled out in the form of wire as small as seven one- "thousandths of an inch in diameter and over a foot "in length, and the same may be coated with a non- "conducting non-carbonizing substance and wound on "a bobbin, or as a spiral, and the tar carbonized in a

"closed chamber by subjecting it to high heat, the 257
"spiral after carbonization retaining its form."

The new departure in the art thus described embodies several features of importance: (1) The carbon burner has a small cross-section and presents a small radiating surface even when given considerable length. (2) The filamentary carbon burner is made of a peculiar kind of carbon, *i. e.*, one produced by the carbonization of a material the volatile portions of which pass off during the carbonization, leaving a porous carbon residue of high resistance. (3) The filamentary burner is 258
made by first reducing the material to the size required, or selecting a material already in the proper form, and then carbonizing it. (4) An exhausted and sealed glass bulb is employed to contain the burner, which bulb, as we afterwards see, is made of an entire piece of glass closed at all points by the fusion of the glass and capable of maintaining a vacuum, as distinguished from the separable lamp-chambers with cemented joints before employed.

The patent next describes the use of platinum wires 259
for carrying the current to the peculiar burner. These are secured to the burner by a carbon paste which insures an intimate contact. The method of doing this forms the subject of the fourth claim of the patent.

The specification then gives the principal advantage which in the mind of the patentee arises from the use of the peculiar carbon burner already described. It says:

"By using the carbon wire of such high resistance
"I am enabled to use fine platinum wires for leading- 260
"wires, as they will have a small resistance compared "to the burner, and hence will not heat and crack the "sealed vacuum-bulb. Platina can only be used, as "its expansion is nearly the same as that of glass."

With respect to the various materials employed in the manufacture of the peculiar burner the patentee states:

"I have carbonized and used cotton and linen "thread, wood splints, papers coiled in various ways, "also lampblack, plumbago, and carbon in various

261 "forms, mixed with tar and kneaded so that the same "may be rolled out into wires of various lengths and "diameters. Each wire, however, is to be uniform in "size throughout."

To enclose the burner in its receiving chamber it is, according to the patent, "placed on the glass holder, "and a glass bulb blown over the whole, with a lead- "ing-tube for exhaustion by a mercury-pump. This "tube, when a high vacuum has been reached, is "hermetically sealed."

262 In addition to the features already alluded to, the patent refers to the difficulty which may arise from distortion of the burner during carbonization and suggests one method of preventing it. It also describes the coiling of the carbon wire forming the burner in a close spiral before carbonization in order to further reduce the extent of the radiating surface. The patent is not, however, to be limited to this shape of the incandescent conductor, since other shapes are alluded to in the specification and this and other shapes were
263 old in the art.

The spiral shape of the burner is illustrated by the drawings of the patent, the description of which is as follows:

"In the drawings, Figure 1 shows the lamp section- "ally. *a* is the carbon spiral or thread. *c c'* are the "thickened ends of the spiral, formed of the plastic "compound of lampblack and tar. *d d'* are the platina "wires. *h h* are the clamps, which serve to connect "the platina wires, cemented in the carbon, with the
264 "leading-wires *x x*, sealed in the glass vacuum bulb. "*e e* are copper wires, connected just outside the bulb "to the wires *x x*. *m* is the tube (shown by dotted "lines) leading to the vacuum pump, which, after "exhaustion, is hermetically sealed and the surplus "removed.

"Fig. 2 represents the plastic material before being "wound into a spiral.

"Fig. 3 shows the spiral after carbonization, ready "to have a bulb blown over it."

The leading wires *x x* are of platinum, as the patent 265
itself states.

The first claim of the patent in suit is as follows:

"1. An electric lamp for giving light by incandes- "cence, consisting of a filament of carbon of high "resistance, made as described, and secured to metallic "wires, as set forth."

This claim being for an electric lamp includes as an obvious element a suitable enclosing chamber, otherwise the burner will be instantly consumed if exposed while incandescent to the air. The particular lamp 266
chamber or globe described in the patent is an exhausted chamber of an entire piece of glass hermetically sealed by the fusion of the glass, and is the only one I know of which is practically useful.

The "filament of carbon" of the first claim is the burner of the lamp and is referred to in the specification as the filament and also as the "carbon wire," the "carbon thread," and as simply "the carbon." The term "carbon filament" was applied to the burner of an incandescent electric lamp for the first time in the 267
history of the art in this patent. The word "filament" means, primarily, a thread-like body; and I understand the term "carbon filament" to involve a carbon conductor of a small or thread-like cross-section. Since the patent says that the carbon wires may be "of various lengths and diameters," I think this descriptive term finds its best definition in the results which the patentee accomplishes by the use of a carbon burner of relatively small cross-sectional area in place of the old carbon burners, which the patentee speaks of as 268
"rods."

In referring to the old lamps the patentee says:— "that owing to the low resistance of the lamp, the "leading wires must be of large dimensions and good "conductors, and a glass globe cannot be kept tight at "the place where the wires pass in and are cemented." Of his own lamp the patentee says:

"By using the carbon wire of such high resistance I "am enabled to use fine platinum wires for leading- "wires as they will have a small resistance com-

269 "pared to the burner, and hence will not heat and "crack the sealed vacuum bulb. Platina can only be "used, as its expansion is nearly the same as that of "glass."

That is to say, the filamentary carbon-burner permits the use of a moderate current of electricity, which enable wires of platinum, although one of the poorest conductors among metals, to be employed; wires which while small enough in size to be readily sealed into the glass chamber, yet will carry the moderate current to
270 the burner without heating to an extent which will crack the glass around the points of sealing. This is a direct result of the employment of a carbon burner of small cross-section and is independent of the length of the burner, since the same flow or quantity of current is required to heat the burner no matter how much it may vary in length; and the conditions referred to in the portions just quoted from the specification are dependent upon the quantity of the current. The filamentary carbon burner
271 also gives a small radiating surface, and a high resistance (and a small mass) per unit of radiating surface, which conditions permit a subdivided light to be practically made and economically employed, since they enable a current of moderate volume to raise the burner to an economically high temperature; and the burner when at an economically high temperature, will, owing to its small radiating surface, give an adequate light, such, for example, as that of an ordinary gas jet. There are other characteristics contributing to the
272 success of incandescent lamps arising from the small cross-section of the burner, such as the ability to maintain effective electric contact between the wires and the carbon burner. This is another respect in which all prior lamps, so far as I know, failed. Carbon is peculiar in that it makes poor electric contact with conductors brought into connection with it. The telephone takes advantage of this fact in its operation. The poorer the contact the greater is the resistance to the flow of the electric current. The heat generated being, according to the well-established law, proportional to

the square of the current, twice the current means four 273
times the heat at the contacts, three times the current, nine times the heat, and so on; and since undue heating at the contacts between the carbon burner and the wires results in an arc-action which rapidly destroys the burner, the necessity for a construction such as is supplied by the patent in suit, which will operate with a moderate current, is apparent.

Another advantage of the filamentary carbon burner is that it does not give up to the contacts and the leading wires a large amount of heat. This results in a saving 274
of energy and more especially prevents the danger to the contacts and to the sealing which would arise from the greater amount of heat conducted back to the contacts and leading wires by burners of larger cross section. This heat is in addition to that produced by the resistance to the passage of the current in the leading-wires themselves and at the points of contact.

These advantages are all independent of the length of the burner and result from a small cross-section.

An increase in the length of the filament gives the lamp 275
a high total resistance and enables it to be used in a multiple arc arrangement, which is the way in which incandescent lamps are principally used at the present time. Such use, however, relates to conditions external to the lamp. The difficulties existing in the construction of the lamp itself were removed, so far as the filamentary burner goes, not by the length of the filament of carbon, but by the fact of its small cross-section.

These considerations lead to the conclusion that the 276
"filament of carbon" of the first claim is a carbon conductor of any length and of a cross-section sufficiently small to produce the important results which have been referred to. Another characteristic resulting from the filamentary form of the burner, is that of elasticity and flexibility, in virtue of which the burner can be attached to terminals rigidly fixed in position, and this without endangering the integrity of the filament from shock or expansion.

The "high resistance" stated in the first claim refers,

277 in my opinion, to "carbon of high resistance," *i. e.*, to
carbon (in a filamentary form) such as is produced by
the well-known process of carbonization, and which, as
compared with the varieties of carbon used in the only
kind of electric lighting in commercial use at the date
of the patent (arc lighting), has a high resistance; this
being the only kind of carbon described in the patent.
The carbon of high resistance reduces the mass of the
filament by its porosity, and reduces the current required
to heat this filament up to the proper light-giving in-
278 candescence. Hence the specific character of the
carbon helps the filament in all the respects in
which the filamentary form is itself advantageous.
In fact it makes the filament, electrically, smaller in
size. This view that "high resistance" in the first
claim refers to the character of the carbon is confirmed
by the expression "made as described," which follows
it, and which means, in my opinion, the making of the
burner by first giving the material before carboniza-
tion and when it can be easily manipulated, the
279 filamentary form, and then subjecting it to carboni-
zation. This is the only practicable way, so far as I
know, of making a filament of carbon uniform in
size and in degree of carbonization, and is the
method called for by the specification. In short it
seems to me that the "filament of carbon of high resist-
ance" of the first claim is to have certain characteristics
which can be given it only by shaping the material and
then carbonizing it. Whether it has these character-
istics or not could be determined at once by the skilled
280 electrician. The securing of the carbon filament to
metallic wires which is referred to in the claim is, like
a suitable receiving chamber, necessary to the opera-
tion of the lamp. This may be done in the particular
way described in the patent, or in other ways calculated
to serve the purpose.

The second claim of the patent in suit is as follows:

"2. The combination of carbon filaments with a re-
"ceiver made entirely of glass and conductors passing
"through the glass, and from which receiver the air
"is exhausted, for the purposes set forth."

This claim covers the combination of a carbon fila- 281
ment as a burner with a peculiar receiving chamber and
with platinum conductors sealed into the glass for leading
the current to the burner. The term "carbon filaments"
should obviously be read "carbon filament" to make
the claim correspond with the description, since the
only lamp described has but one filament. The limita-
tions of making the filament of a particular kind of
carbon and in a particular way, which appear in the
first claim, are not made features of the second claim.
The term "carbon filament" of the second claim is 282
synonymous with "filament of carbon" of the first
claim; *i. e.*, the filamentary form is preserved in both
claims. The "receiver" of the second claim, I un-
derstand to be one made of an entire piece of glass,
i. e., with all joints closed by the fusion of the glass;
and this is to be exhausted. Such a receiver is capa-
ble of maintaining a vacuum which the old lamp
chambers, being jointed, could not do, and a vacuum is
essential to the durability of the burner as well as to
economy in its operation, since when any gas at atmos- 283
pheric pressure is present in the receiver the same
amount of light is secured only by the employment
of many times the current. This use of a vacuum is
another factor entering into the employment of a mode-
rate current, the beneficial results of which in several
directions I have already pointed out.

The fact that a vacuum is essential to the dura-
bility of the carbon burner is referred to in the patent
in suit as follows:

"The use of a gas in the receiver at the atmospheric 284
"pressure, although not attacking the carbon serves to
"destroy it in time by 'air-washing' or the attrition
"produced by the rapid passage of the air over the
"slightly coherent highly heated surface of the carbon."

The "conductors passing through the glass" of the
second claim, I understand to refer to the platinum
wires which are sealed into the glass walls of the re-
ceiving chamber by the fusion of the glass upon them
and which serve to carry the current to and lead it from
the carbon filament within the receiver.

285 Referring now to the defendant's three lamps men-
tioned in the question, I am of the opinion that each of
the three lamps embodies in its construction the invention
set forth in the first two claims of the patent in suit.
Each has all the elements of each of said claims com-
bined and operating in the same way and for the same
purpose. This is apparent from an inspection of the
lamps put in evidence and from the admission of de-
fendant's counsel.

The burner in each lamp is a filament of carbon,
286 possessing all the substantial advantages of the filament
of carbon of the patent. It is made from the same kind
of carbon as the filament of the patent, *i. e.*, one pro-
duced by the carbonization of a carbonizable material,
and it is made in the same way, *i. e.*, by reducing the
material to size before carbonization; it therefore has
the same characteristics as the carbon filament of the
patent in suit. The inclosing chamber of each of the
lamps of the defendant is the same as that of the pat-
ent, it being made of an entire piece of glass closed at
287 all points by the fusion of the glass, and it is exhausted
of air. The wires leading the electric current to the
carbon filament are platinum wires, and pass through
and are sealed into the glass the same as in the patent
in suit.

In arriving at the above conclusions I have not over-
looked the fact that the filaments in defendant's lamps
are not coiled in a spiral neither are the wires secured
to the filaments by a carbon paste, and in one instance,
the defendant's tamidine lamp, a carbonizable material
288 is employed for producing the filament, (viz., tamidine),
which is not specifically named in the patent. But these
differences I consider immaterial. The close coiling of
the filament became unnecessary when a steady current
of electricity was employed, since the "flickering of the
light" was no longer appreciable to the eye. Spirals and
other shapes had been proposed for incandescent con-
ductors before the date of the patent, and the descrip-
tion of the patent itself, I understand, contemplates any
suitable shape. The use of mechanical clamps instead
of a carbon paste for connecting the burner with the

leading wires of an incandescent electric lamp, was old 289
at the date of the patent. At the present date a carbon
paste, I believe, is more largely used for this purpose
than mechanical clamps, but either is an effective
arrangement. The tamidine employed in the manufac-
ture of the filament in one of the defendant's lamps is a
non-fibrous material, though made from substances
originally fibrous. But the patent itself contemplates
the employment of non-fibrous as well as of fibrous
material. This difference in material is one merely of
detail of construction. Many different materials are at 290
present employed for this purpose by the various man-
ufacturers of incandescent electric lamps throughout
the world. The complainant company uses bamboo.
Another manufacturer employs silk thread. But they
all attain the results set forth in the patent in suit, and
in substantially the same way.

6 Q. What influence or effect had the invention in
suit upon the art of electric lighting; and to what ex-
tent, so far as you know, has the same been publicly in-
troduced? 291

A. As a contribution to the art of electric lighting I
attribute the greatest importance to the invention of
the patent in suit. Indeed, in my judgment, it is not
too much to say that this invention was practically the
creation of a new art in lighting by electricity. Al-
though for more than forty years attempts had been
made by previous experimenters to produce light by
incandescence, yet all these attempts seem to have been
commercially failures. A practically successful incandes-
cent lamp was unknown, I believe, up to the time of 292
the appearance of the invention described in the patent
in suit. But at once upon the appearance of this pat-
ent it was generally recognized, I believe, that Mr. Edison
had solved the problem of the practical subdivision of
the electric light and had produced a lamp possessing
the indispensable requisites of high economy, durability
and simplicity of construction. Thereupon capital be-
gan to embark in the various projects for the illumination
of cities and towns by electricity in place of gas, which
the new invention rendered possible. Central stations

293 were rapidly introduced both in this country and Europe. Factories were erected in all leading countries to provide the devices necessary to the new incandescent system, and to-day the Edison Company alone reports one hundred or more such stations in the United States, upon the circuits of which more than one million incandescent electric lamps are connected; all of which lamps have been made under the patent in suit, and embody the elements set forth in the first and second claims. It is clearly my opinion that no single inven-
294 tion in the electric art has done more to revolutionize our methods of household illumination. The invention of Mr. Edison, which is set forth in the patent in suit, has enabled the world to replace combustion methods of lighting by electrical methods; has rendered it possible to prevent the consumption and corruption of the air we breathe, and has given us an electric light of practically an equal economy, which leaves to us that oxygen which is so essential; a light which, being unaccompanied with the heat energy consequent upon combus-
295 tion, not only can be furnished more economically, since its light energy is a larger total fraction of the whole expended, but is of greater practical utility, since the deleterious heat effects of gas flames and the like are almost entirely absent.

With reference to the importance of the said Edison invention, the fact is significant that while no commercially successful incandescent lamp, so far as is known to me, was in use prior to the date of the said Edison patent, such lamps constructed substantially according to
296 the principles of the said invention came into extensive use immediately thereafterward, and in enormous numbers. So that to-day all of the incandescent electric lamps in use with which I am acquainted embody the said principles of construction.

7 Q. For the purpose of preserving *fac-similes* of the defendant's lamps, Complainant's Exhibit Defendant's Zig-zag Lamp, Complainant's Exhibit Defendant's M-Lamp and Defendant's Tamidine Lamp, in case the exhibits themselves should be broken before the hearing, drawings having been prepared purporting to represent

these exhibits severally, will you please look at such 297
drawings and state whether the same accurately and correctly represent such exhibits severally, both as to their elements and method of combination of such elements, stating in your answer what you find in detail in such drawings severally?

A. I have examined the said drawings and have compared them with Complainant's Exhibit Defendant's Zig-zag Lamp and Complainant's Exhibit Defendant's M-Lamp. The drawing of the zig-zag lamp represents
also the tamidine lamp of the defendants, as I under- 298
stand from the admission of defendant's counsel here in evidence. In the drawing of defendant's zig-zag and tamidine lamps I have marked the filamentary carbon burner, *a*, the platinum leading wires, *b* and *b'*, and the glass enclosing receiver, *c*. Like the lamps themselves the drawing shows a burner of small cross section (*a*) combined with a receiver made entirely of glass, with metallic conductors (marked *b*, *b'*) passing through and sealed into the glass and serving to lead a current
to the burner, together with a projection at the top of 299
the lamp showing the point where the lamp was sealed after it had been exhausted. This point I have marked *d*.

In "Complainant's Exhibit Drawing of Defendant's M-Lamp" I have marked the filamentary carbon burner *a*, the leading in wires *b* and *b'*, the enclosing globe of glass, *c*, and the point where the bulb is sealed after exhaustion, *d*. In this drawing, as in the lamp itself, I find a filamentary burner of small cross section (*a*) of
carbon secured to platinum wires passing through the 300
glass, the filamentary burner being enclosed in a receiver made entirely of glass, from which receiver the air has been exhausted, as is shown by the projection at the top marked *d*. The two drawings above referred to show the carbon burner of a different shape in the two, the one being of a zig-zag shape and the other of an M-shape, from which evidently the names come which have been given to these lamps.

A comparison of the two drawings with the lamps themselves corresponding to them, and herein in evi-

301 dence as exhibits, shows that the said drawings accurately and correctly represent the said lamp exhibits. They have, as I have stated above, the same elements of construction, to wit, the filamentary carbon burner of small cross section and high resistance, the enclosing chamber made entirely of glass and closed by the fusion of the glass, the platinum conducting wires passing through the glass and to which the filamentary burner is secured, the said receiver or enclosing chamber being exhausted of air. These elements are combined in the
302 same way, apparently, in the drawings as they are in the lamp exhibits.

The drawings referred to by the witness are offered in evidence and are marked "Complainant's Exhibit Barker's Drawing of Defendant's Zig-zag and Tamidine Lamps," and "Complainant's Exhibit Barker's Drawing of Defendant's M-Lamp. S. M. H., Ex'r., October 21, 1889.

303 Adjourned to meet at the office of complainant's counsel, R. N. Dyer, Esq., 40 Wall street, New York, on Friday morning, 25th inst., at 10:30 A. M.

Friday, Oct. 25, 1889.

304 Met pursuant to adjournment.

Present—Counsel as before and the cross-examination of Professor Barker by Samuel A. Duncan, Esq., defendant's counsel, proceeded as follows:

8 x-Q. I assume from your statements in this case, and from the fact of your long professional employment by the Edison Company in connection with their litigation under patents relating to incandescent electric lighting, that you regard yourself as thoroughly

familiar with the state of the art at the date when Mr. 305
Edison made the alleged invention which forms the subject of the patent in suit. Is this assumption correct?

A. I have endeavored to keep myself informed of the progress made in incandescent electric lighting and believe that I am reasonably familiar with the state of the art at the time when the application for the patent in suit was filed.

9 x-Q. When first, so far as you know, was the discovery made that for the purpose of effecting the prac- 306
tical subdivision of the electric light, produced by incandescent lamps arranged in multiple arc, it was necessary that the "burner" (or incandescent conductor) of the lamp should be made of high resistance?

A. My recollection is that the first distinct statement of the importance of high resistance in an incandescent lamp was made in the year 1878.

10 x-Q. By whom?

A. I find in a patent to St. George Lane Fox, dated October, 1878, the statement referred to. 307

11 x-Q. Was that prior to the application for the patent in suit?

A. It was.

12 x-Q. Then so far as the invention disclosed by the patent in suit depends upon introducing into the lamp a burner having a high resistance, the patent does not disclose any principle that was not known to the world prior to the date of Mr. Edison's application for said patent?

A. Mr. Lane Fox having recognized the importance 308
of high resistance and having stated it in his patent, it follows, I think, that the bare fact of this importance was already known and therefore is not disclosed for the first time in the patent in suit. That is to say, high resistance was known to Lane Fox only as an unattained desideratum.

13 x-Q. Was there, to your knowledge, prior to the date of Edison's application for the patent in suit, any other patent or printed publication besides the patent

309 of Lane Fox to which you have referred, in which the principle of high resistance in the burner was set forth as a feature essential to the practical subdivision of the incandescent electric light?

A. Mr. Edison himself recognized and stated the importance of the principle of high resistance in using lamps in multiple arc in his English patent of 1879.

14 x-Q. Is it not within your personal knowledge that he recognized and practically applied this principle in connection with his platinum lamps as early as
310 the latter part of 1878, and that the knowledge of such fact was given to the world at that time in connection with the published accounts of that lamp?

A. My recollection is, that he did recognize the importance of high resistance in an incandescent lamp as early as the fall of 1878, and that he constructed platinum lamps about that time, in which he sought to attain the desired high resistance, but without satisfactory results; hardly more so, perhaps, than those obtained by Lane Fox in the same direction. As I understand the
311 matter, the failure of the platinum lamps in Edison's case, as in that of Lane Fox, arises from the impossibility of obtaining with a platinum burner a sufficiently high resistance. The experiments of Mr. Edison were, I believe, described in various printed publications at the time.

15 x-Q. You yourself, I believe, visited Menlo Park in November, 1878, and there saw a large plant of these platinum lamps in operation, and subsequently in the same month gave a public lecture in the Academy of
312 Music in Philadelphia, in which among other things, you gave the public a description of the invention?

A. I remember visiting Menlo Park about the time referred to, and I also remember seeing the platinum lamp in operation. I gave a lecture in the Academy of Music in Philadelphia, in the fall of 1878. But I did not see in Menlo Park a large plant of these platinum lamps in operation, and my recollection is, that I did not give in the lecture referred to any description of the said lamp.

16. x-Q. Did you not in the said lecture, referring to 313
the lamps which you had seen on the occasion of your visit to Menlo Park, referred to in your last answer, make the following statement, or at any rate use words of the same substantial import as the following statement, to wit:

"I hoped to be able to exhibit the famous light, but I am informed by Professor Edison that advices from his London solicitors prevent him from making his invention public for twenty days yet, and therefore I have to wait; but within a week I have 314
visited Menlo Park, and after a thorough examination of Mr. Edison's discovery, I can say that the problem has been solved and that Mr. Edison can place on every gas bracket and on every chandelier burners which will give a brilliant white light, safe, pleasant, beautiful, and at about $\frac{1}{3}$ the cost now charged for gas. The practicability of the scheme is beyond question."

Objected to as incompetent, irrelevant, and not founded on the examination-in-chief. 315

Witness says: "Please show me the reference from which you have quoted."

The counsel for the defendant says he does not deem this necessary.

A. In the absence of any evidence to the contrary, I assume that the quotation in question is taken from a report of the lecture published in a newspaper and subject to the errors of detail found in such reports.

My recollection is, however, that I did give the 316
reason stated for not showing or describing the lamp. And further that I expressed the opinion that Mr. Edison was upon the right track, and that at that time the experiments which he had already made seemed to me to promise a fair prospect of success.

17 x-Q. Were you not at that time, and for a considerable time afterwards, very enthusiastic with reference to the platinum lamp which Mr. Edison exhibited to you at Menlo Park, and did you not believe, and so express yourself to many of your friends, that Mr. Edison

317 had by that invention practically solved the problem of incandescent lighting?

Same objection as last above.

A. I do not remember to have been either at that time, or at any time thereafter, "very enthusiastic" about the success of the platinum lamp. I believed, as I stated in my last answer, that Mr. Edison was upon the right track; that so far as the principle involved
318 was concerned it was theoretically correct; and that provided it could be satisfactorily put into execution, his lamp would be a success. It is possible that having these views I may have expressed them to others.

18 x-Q. What was "the principle involved" in Mr. Edison's platinum lamp, which you deemed to be "theoretically correct," as referred to in your last answer?

A. "The principle of high resistance" as stated in cross-question 13.

319 19 x-Q. Do you mean to be understood as saying that in your opinion the principle of high resistance in the burner as a feature essential to the practical subdivision of the incandescent electric light as such principle was embodied in Mr. Edison's platinum lamp of 1878, was theoretically correct?

A. I mean to say that the principle of high resistance is, in my judgment, a theoretically correct principle so far as the question of securing an economically successful subdivision of the electric light by incandescence
320 in multiple arc circuits is concerned. If it had been possible, as I understand the matter, to secure an economically high resistance in a platinum burner, Mr. Edison's platinum lamp might have been successful. It was a step therefore in the right direction, but as it turned out, it did not go far enough.

20 x-Q. So far as concerns the necessity of using a burner of high resistance in order practically to effect the subdivision of the incandescent electric light, is not the principle or necessity precisely the same whether

the burner be composed of platinum or carbon or any other material? 321

Same objection.

A. I suppose that it is. That is to say, an incandescent lamp to be economically successful must, I think, have a burner of high resistance, and this irrespective of the material of which the burner of the said lamp is made. As a matter of fact, however, carbon is preferred as the material of the burner since 322
its specific resistance is higher than that of any other available substance thus far tried.

21 x-Q. Generally, is it not a necessary consequence of the well known and long established laws of electricity, that in order practically to effect the subdivision of the electric current among a large number of electrical translating devices arranged in multiple arc (whether such translating devices be incandescent lamps, telegraphic instruments, electric motors, gas lighters or other devices), it is necessary to give to such 323
translating devices a high internal resistance?

A. It is true, as it seems to me, that the use of transacting devices in multiple arc in order to be economically successful requires that these translating devices be of high resistance. And it is equally true, I think, that this result is in accordance with the well established laws of electrical science. Indeed, that is what I meant when I said that the principle of high resistance was theoretically correct.

22 x-Q. It is also true, is it not, that this law of 324
physics which governs the subdivision of the electric current was well known to the scientific and the industrial world many years before the date of Edison's application for the patent in suit?

A. I do not understand that any single law of physics governs the subdivision of the electric current; or as I should prefer to say, governs the subdivision of the electric light. The physical laws upon which the practicability of an economical subdivision of the electric light in multiple arc depends have been known, I

325 believe, for a long time. But I do not believe that the conditions necessary to economically subdivide the electric light, even although they have been subsequently found to be in entire accordance with those laws, were at all well known or recognized before the date of application for the patent in suit. In proof of this opinion I recall the fact that Mr. Schwendler, one of the ablest of English telegraphic engineers, said in 1879, "if more than one light is produced in the same circuit by the same current, the external or available
326 light becomes rapidly dearer with increase of the number of lights produced. For this reason already, if not for many others, the division of light must result in an engineering failure." Such a statement seems to me to show that while fundamental laws may be well-known, obvious consequences from those laws may be entirely lost sight of.

23 x-Q. Evidently you have not caught the point of my last question. I wish to know from you whether it was not well known to both the scientific and indus-
327 trial world many years before Edison's application for the patent in suit that in order practically to effect a subdivision of the electric current among a large number of translating devices arranged in multiple arc, whatever the nature of the translating devices, it was necessary to give to such translating devices a high internal resistance.

A. As a matter of fact I do not think that it was. In the 9th cross-question I was asked when the discovery was first made that for the purpose of effecting the
328 practical subdivision of the electric light, it was necessary that the burner of the lamp should be made of high resistance. And I answered that according to my recollection the first distinct statement of the importance of high resistance in an incandescent electric lamp was made in the year 1878. The present question seems to me to ask essentially whether what I had stated was first made known in 1878 was not known many years before the application for the patent in suit.

24 x-Q. Is it not a fact that local telegraphic sounders

were arranged in multiple arc (or in parallel) several 329
years prior to 1879?

Same objection.

A. The fact stated, if it be a fact, has never happened to come to my knowledge. Moreover such sounders as I am familiar with have been of low resistance.

25 x-Q. If it were a fact that twenty years ago telegraphic sounders were arranged in multiple arc, would
it have been necessary for their practical and economi- 330
cal working to give them a high internal resistance as compared with the rest of the circuit?

Same objection.

A. I think that the economical working of the said sounders would be improved by making them of high resistance.

26 x-Q. Do you not recall the fact that several years
ago, prior to 1879, translating devices used in con- 331
nection with gas burners, for lighting gas, had been arranged in parallel or multiple arc, notably in the Capitol at Washington?

A. I know that such devices have been used in branch circuits. But I do not understand that such devices have been used in multiple arc on closed circuits; that is, with all the branches constantly closed and the current constantly flowing through them all. Indeed, my recollection is that the cross or parallel circuits, on each
of which a gas-lighting device is placed, are constantly 332
open, and are closed only for an instant, and this consecutively at the moment of lighting the gas.

27 x-Q. Still it is a fact, is it not, that such translating devices were arranged in multiple arc in a circuit which was necessarily closed during the flow of the current?

A. It is.

28 x-Q. And for some years before 1879?

A. I believe so.

29 x-Q. Was it not necessary to the practical and

333 economical working of these translating devices used for gas lighting, when arranged in multiple arc, that they should have a high resistance?

A. In so far as the branch circuits were simultaneously closed, I should suppose that the economy of their working would be increased by making the devices of high resistance.

30 x-Q. Was not the knowledge which leads you to make this last statement in possession of the scientific and industrial world at the time when these translating
334 devices used for gas lighting were first arranged in multiple arc?

A. If the devices referred to were of high resistance, and were so used in multiple arc, I think that the knowledge which enabled the utility of this arrangement to be recognized must have been public knowledge.

Adjourned to meet at the office of complainant's counsel, R. N. Dyer, Esq., 40 Wall street, New York,
335 on Saturday morning, the 26th inst., at 10½ A. M.

SATURDAY, October 26th, 1889.

Met pursuant to adjournment.

Present—Counsel as before, and the cross-examination of Professor BARKER by SAMUEL A. DUNCAN Esq., defendant's counsel, proceeded as follows:

336 31 x-Q. Are you not familiar with the United States patent of Samuel Gardiner, No. 125,387, of April 9th, 1872, for "Improvement in distributing electricity for gas lighting and other purposes"?

A. I think that I am.

32 x-Q. Does not that patent provide for arranging the translating devices in multiple arc and for giving those devices a high resistance?

Same objection and that the patent is the better evidence.

A. The patent shows and describes the translating 337
devices arranged in multiple arc circuits, but I do not find in the patent evidence that these translating devices are of high resistance. The patent speaks of a resisting coil used "to resist the battery power." It further says, "in order that the supply furnished to "any one place be not too great, I find it necessary to "employ a means of disposing of the surplus over that "actually sufficient for the one place. For this pur-"pose I have devised what I call a resisting coil." All this seems to me to show that these coils were used as 338
equalizing coils and this, I think, is consistent with their being of low resistance.

33 x-Q. If, in 1872, you had been called upon to erect a plant for lighting gas by electricity which would operate practically and economically and which plant would embody the invention set forth in the said Gardiner patent, would you not have made the translating devices of high resistance relatively to the main circuit?

A. I do not find in the said Gardiner patent any 339
distinct statement as to the nature of the translating devices employed for producing the desired result, viz.: lighting the gas. Assuming, however, that the device used in the apparatus of Gardiner is a coil of platinum wire, I should certainly have made this coil of relatively high resistance; and this whether it was to be used on a single circuit or on multiple circuit.

34 x-Q. Would not the relative resistance of the individual translating devices as compared with that of the rest of the circuit necessarily have been much 340
higher with a large number of the translating devices arranged in multiple arc than would have been the relative resistance of a single translating device to the rest of the circuit when only one translating device is used; assuming, of course, that the plant is constructed with reference to economy of working?

A. I think that the case supposed is simply one under the general principle that the greater the resistance of a circuit, whether simple or compound,

341 the less the current flowing in the circuit and consequently the less the consumption of battery material.

With a constant potential difference on the mains and a low internal resistance in the generator, it is well known that the current flowing through the different branches of a multiple arc circuit is the same through each branch if the resistances are the same and is inversely as the resistances if they are not. The total resistance of a number of branch circuits, supposed equal to one another, is represented by the resistance of one
342 such circuit, divided by the number of circuits. In
order, under these circumstances, that the total resistance of a divided circuit should equal the resistance of a circuit carrying the same current and composed of only a single branch, it would be necessary to make the resistance of each branch circuit greater in proportion to the number of circuits.

My embarrassment in answering the question arises from the fact that in this case, as well as in all other cases where a battery is used as the electrical genera-
343 tor, this battery is an additional variable.

In the case supposed, for example, if the battery as well as the translating devices be arranged in multiple arc, the system, as it seems to me, would be practically inoperative. If, on the other hand, the battery were arranged in series, the resistance of the battery itself would increase proportionately to the number of cells employed. If a combination of series and multiple arrangement were employed, then, I think, in order to answer the question of economy in the arrangement of the
344 exterior circuit, it would be necessary to know what
the particular arrangement of the battery is in the particular case inquired of.

My impression is, however, that owing to the small amount of current used by such devices as the electric lighting apparatus of Gardiner, and as telegraphic instruments in general, the question of economy, so far as the resistance of the devices in use on the external circuit are concerned, is a comparatively unimportant one; other considerations, such as those of construction and the like, being of more significance. In fact,

so far as I know, economy in telegraphic and similar 345
systems has never been made to depend practically upon the relative resistance of the devices in the external circuit.

35 x-Q. In answer to cross-question 25, you said that under the assumption that telegraphic sounders were arranged in multiple arc twenty years ago, you "think "that the economical working of the said sounders "would be improved by making them of high resist- "ance." Why do you so think?

A. I think so for the reasons that were stated in my 346
last answer. In my 19th cross-answer I expressed the opinion "that the principle of high resistance is, in my "judgment, a theoretically correct principle, so far as "the question of securing an economically successful "subdivision of the electric light by incandescence in "multiple arc circuits is concerned." Provided, therefore, that telegraphic sounders are to be considered translating devices in the same general sense as incandescent lamps, and provided that all other things are
equal (such as circuit, generator, etc.), I think that an 347
increase in the resistance of a sounder will improve its economical working.

That this is not necessarily so, however, seems to me to follow, from the fact that the efficiency of a sounder is dependent upon the ampere-turns on its magnet. So that its efficiency might be reduced by increasing its resistance.

36 x-Q. I call your attention to page 55 of a work on the electric telegraph written by Frank L. Pope, and
published by Van Nostrand in 1874, and ask you 348
whether you would now be prepared to admit the fact set forth in cross-question 24?

Objected to.

A. I am, although I do not find any evidence at the place cited that the sounders employed were of high resistance.

All of the foregoing answer after the first two

349 words objected to as relating to a matter not inquired about in the question.

37 x-Q. Do you not, however, find evidence that the sounders were of high resistance as compared with the rest of the circuit?

A. I find no statement at the place cited of the resistance of the sounders used nor of the battery resistance; and the matter does not seem to me to be determinable from the drawing.

350 38 x-Q. Assuming the sounders to be the usual standard resistance of four ohms and that the battery shown is the usual battery employed for such purpose—about one ohm per cell—what then would you answer to the last question?

A. Of course if the resistance of the sounder be assumed as four ohms, and the resistance of the two batteries in series be two ohms, it follows that the resistance of each single sounder is twice the resistance of each single pair of batteries in series and six times the
351 resistance of the three pairs of batteries in multiple. But I should not call a sounder of four ohms resistance a sounder of high resistance *per se*: nor do I think that in general I should call a resistance six times as great as another a high resistance as compared with that other. It seems to me, moreover, that one ohm is a low resistance for the average battery cell.

39 x-Q. Having lately served the Edison Electric Light Company as an expert in their suit against Westinghouse, Church, Kerr & Co., I presume that you are
352 familiar with the French patent of Khotinsky, Number 107,207, of March 19th, 1875, and with the U. S. Patent of H. Woodward, Number 181,613, of August 29th, 1876?

A. I have read the said patents and believe that I am more or less familiar with them.

40 x-Q. Both of these patents provide, do they not, for the arrangement of incandescent lamps in multiple arc?

Same objection.

A. They do. 353

41 x-Q. If, at the respective dates of those patents, you had been called upon to erect an electric lighting plant with the lamps arranged in multiple arc as provided in said patents, would you not have endeavored to so construct the lamps as to give them individually a high resistance relatively to the main circuit?

A. It is extremely difficult at this late day when the principles which govern the economical application of electricity to the problem of incandescent electric lighting are so well known and so generally recognized, to 354
carry one's self back to those early days and to say exactly what the knowledge of that day was. As a matter of fact, I find that both of the patentees referred to, that is, Khotinsky and Woodward, used on their circuits lamps of low resistance; that is, as I suppose, lamps whose resistance was not over one or two ohms. It seems reasonable to suppose, I think, that these inventors were acquainted with the state of the art as it existed at the time when they applied for their patents. And hence it seems to me that the principle of high resistance, 355
in the form and for the reason for which it is now used was not common knowledge at the dates referred to.

In further support of this opinion I may mention the statement made in my 22d cross-answer, viz.: That so eminent an authority in electricity as Mr. Schwendler expressed the opinion that for many reasons "the division of light must result in an engineering failure." Moreover, I find that Mr. Schwendler expressed in 1879 the further opinion that, "Unless we should be fortunate enough to discover a conductor of electricity with a 356
much higher melting point than platinum, and the specific weight and specific heat of which conductor is also much lower than that of platinum, and which at the same time does not combine at high temperatures with oxygen, we can scarcely expect that the principle of incandescence will be made use of for practical illumination."

"I do not believe, therefore," as I stated in my 22d cross-answer, "that the conditions necessary to economically subdivide the electric light, even although

357 they have subsequently been found to be in entire accordance with these laws, were at all well known or recognized before the date of application for the patent in suit."

If I were now called upon to erect such a plant I should undoubtedly use lamps of high resistance; but I think that I should not have done so at the date of Khotinsky and Woodward. (The statements of Schwendler referred to are to be found in "Van Nostrand's Magazine" and in the "Telegraphic Journal"
358 for 1879.)

Objected to as not responsive.

Adjourned to meet at the Stratford House, in Philadelphia, on Wednesday, October 30th, 1889, at 11 A. M.

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359 "The Stratford,"
Philadelphia, October 30, 1889.

Met pursuant to adjournment.

Present—Counsel as before, and the witness.

Continuation of the Cross-Examination of Professor Barker:

360 42 x-Q. Would you not have endeavored under the hypothesis of the last question to make the resistance of the lamps as high as you might have found practicable consistently with the nature of the material proposed by Woodward and Khotinsky for the burner, and consistently with the methods of manipulating such material which were known at those dates?

A. I understand this question in the same sense as the last, that is, would the state of the art at the time referred to have instructed me to make the resistance of the lamps in question as high as practicable. In my last answer I gave some references to the state of the

art even much later than the dates of Khotinsky and 361
Woodward. Further, I have failed to find described the use of any high resistance lamp in multiple arc circuit before 1878 or 1879. Additional references might be made to show that the knowledge of that day was not sufficient to require the use of high resistance lamps in multiple arc circuit, since the problem to be solved does not depend on the resistance alone, but is a function of other conditions as well. Quotations establishing this imperfect condition of the state of the art even at the time the application for the patent in suit 362
was filed, and, therefore, later than the dates of Khotinsky and Woodward, might be indefinitely multiplied. But a single reference to Mr. Preece's paper in "The Philosophical Magazine" for January, 1879, may be added to those already given. He says:

"The theory of the electric light cannot be brought absolutely within the domain of quantitative mathematics and for the reason that we do not yet know the exact relation that exists between 363
the production of heat and the emission of light with a given current; but we know sufficient to predicate that what is true for the production of heat is equally true for the production of light beyond certain limits. * * * The exact relations between current, heat, temperature, mass and light have yet to be determined by experiment."

Mr. Preece closes his paper with the following words: 364

"It is this partial success in multiplying the light that has led so many sanguine experimenters to anticipate the ultimate possibility of its extensive subdivision—a possibility which this demonstration shows to be hopeless and which experiment has proved to be fallacious."

So far, therefore, as I have been able to ascertain the state of the art at the date of Khotinsky and Wood-

365 ward, I do not find that the knowledge of that day was sufficiently advanced to appreciate the advantages of high resistance in lamps used in multiple arc circuit. I conclude, therefore, that this knowledge would not have instructed me to make the resistance of the Khotinsky and Woodward lamps as high as practicable under the conditions of the question.

Answer objected to as not responsive.

366 43 x-Q. Was it not a matter of common scientific knowledge as early as 1875, and did you not personally know as early as that date, that the ratio of the total energy utilized in translating devices of any kind arranged in multiple arc, to the energy expended in the other parts of the circuit—that is, in the generator and the conductors—is the same as the ratio between the joint resistance of the translating devices and the resistance of the rest of the circuit; and therefore that when such translating devices are arranged in multiple
367 arc, the resistance of each individual device must be high, relatively to the total resistance of the generator and the conductors, in order that an adequate proportion of the total energy may be utilized in the translating devices in doing effective work?

A. I did know in 1875, as a deduction from a law established mathematically by Joule, that the amount of work done in any circuit is proportional to the resistance of that circuit, other things being equal; and therefore under the same conditions that the amount of
368 work done in two parts of the same circuit is proportional to the resistances of those parts.

I also knew at the time referred to, also as a deduction from a law mathematically established by Kirchhoff, that the total resistance of a number of branch circuits is equal to the resistance of a single branch circuit divided by their number; the resistances of the several branches being supposed equal.

It follows, I think, that the total resistance of a number of branch circuits is less than the resistance of a single branch; or what is the same thing, that the re-

sistance of a single branch must be higher than the 369
total resistance of all the branches.

I think that it should be borne in mind, however, in calculating the work done in any circuit, that this work is a function not only of the resistance of that circuit, but also of the strength of the current flowing through it; which current strength again is itself a function of the resistance. The work done in any circuit is proportional to the resistance of that circuit as above stated. But it is proportional to the *square* of the current strength. 370

Thus, for example, as I view the matter, if four lamps were introduced into a circuit consecutively (*i. e.*, in series), the total external resistance would be four times that of a single lamp; and the electro-motive force remaining constant, the current strength will be reduced to one-quarter. Since, as above stated, the work done in the circuit is proportional to the square of the current strength multiplied by the resistance, it follows that the work done under the circumstances supposed would be only one-quarter of that done with a single lamp in 371
circuit.

On the other hand, if the four lamps are arranged in parallel (*i. e.*, in multiple arc), the total resistance as above stated will be one-quarter of that of a single lamp and the current strength in the circuit, the electro-motive force as before being supposed constant, will be four times as great. Hence, the work done in the circuit of the four lamps will be four times as great as the work done when a single lamp only is in circuit.

I think, therefore, that it would not be correct to say 372
that the amount of work done in any circuit is in general directly proportional to the resistance of that circuit; since in the above examples the work in one case was diminished four times by increasing the resistance four times, and in the other the work was increased four times by reducing the resistance to one-quarter.

44 x-Q. My last question assumed, of course, that the current of the circuit was to remain constant, and also that the total resistance of the circuit was to be constant, since the question contained no suggestion of

373 any variation in either of these particulars. The question also was limited to the consideration of translating devices arranged in multiple arc. Keeping in mind these conditions: I now ask you whether the law of distribution of the electric current among the different parts of the circuit as stated in that question, was not matter of common scientific knowledge as early as 1875, and whether you yourself did not have knowledge of that law?

A. I do not see that the result is materially different
374 under the hypothesis of the last question. It is true, as I stated in my last answer, that when the current strength is constant the amount of work done in any circuit is proportional to the resistance of that circuit. I merely wish to have it understood that the amount of work done in a circuit does not depend alone upon the resistance of that circuit.

In answering the last question I assumed a constant electro-motive force, because that is the ordinary condition under which multiple arc circuits for incan-
375 descent lamps are worked. If, however, taking the hypothesis in the question, we assume the current constant, then since the total resistance by hypothesis is also constant, the total energy expended in the circuit must also be constant. In which case the amount of work done in each lamp, as it seems to me, will be inversely as the number of lamps; while the resistance of each lamp (the lamps being supposed alike) would be the product of the total lamp resistance by the number of lamps.

376 To illustrate what I mean suppose, as before, four similar lamps were placed in multiple arc circuit, the current through which and the total resistance in which are by hypothesis constant. Since there are four lamps in parallel the resistance of each lamp for the same total resistance, as I stated in my last answer, will be four times this total resistance. Moreover, since the current is constant and this current passes through four equal lamps, each lamp obviously will receive one-quarter of it; and therefore the energy expended upon each lamp will be one-quarter of the energy expended upon the

four lamps, as stated above. In this case, therefore, we 377
see that the energy expended in a single lamp is only one-quarter of the energy expended in the four lamps arranged in multiple arc, although the resistance of the said single lamp is four times as great as the resistance of the four lamps arranged in parallel.

Answer objected to as not responsive.

45 x-Q. Is it not a fact that the law stated in cross-question 43 was well known to the scientific world, 378
yourself included, prior to 1875?

A. I do not think that I can answer the question better than I have already done. I do not find in cross-question 43 any statement of any law of nature; at least in any form ordinarily given in scientific works. As I stated in my answer to that question, I regard the statement which it contains as deductions from the well-known laws of Joule and Kirchhoff, and the question whether those deductions had been already made in 1875 is a question of fact, as it seems to me. It 379
does not follow that because laws were known at any given time all possible deductions from those laws must have been known at the same time. It is a remark of one of our most eminent electricians that nothing has been discovered in electrical theory since 1872 which was not contained in Maxwell's equations, published in his book at that time.

On the question of fact, therefore, I do not think that I can do better than to quote the following paragraph of my answer to the 42d cross-question, as follows: 380

> "So far, therefore, as I have been able to ascertain the state of the art at the date of Khotinsky and Woodward, I do not find that the knowledge of that day was sufficiently advanced to appreciate the advantages of high resistance in lamps used in multiple arc circuits."

I cannot answer the question, therefore, except by expressing the opinion that while the laws of Kirchhoff

381 and Joule were known before 1875, the deductions from them contained in the 43d cross-question, so far as I understand them, were not common knowledge at that date and did not, so far as I have been able to learn, influence in any way at that time the construction of incandescent lamps.

46 x-Q. Did not you know prior to 1875 that in an electrical circuit in which the total resistance remains constant and the current is constant the current would be distributed among the different branches of the
382 circuit according to the relative resistances of those parts?

A. It is a deduction from Kirchhoff's law that in a branched circuit the current divides itself among the branches in the inverse ratio of their resistances. This I knew prior to 1875.

47 x-Q. Did you not also know prior to 1875 that the current energy expended in the different parts of an electric circuit, the total current and the total resistance remaining constant, would be proportional to
383 the relative resistances of the respective parts of the circuit?

A. It seems to me that I have already answered that question in my answer to cross-question 43. I there said:

> "I did know in 1875 as a deduction from a law established mathematically by Joule, that the amount of work done in any circuit was proportional to the resistance of that circuit, other things
> 384 being equal; and therefore, under the same conditions, that the amount of work done in two parts of the same circuit is proportional to the resistances of those parts."

48 x-Q. That also was matter of common scientific knowledge at that time, was it not?

A. I suppose that it was.

49 x-Q. In view of what in the last two answers you admit to have been matter of common scientific knowledge and personal knowledge of yourself, please state

whether if you had been called upon in the years 1875 385
and 1876 to erect electric-lighting plants with lamps arranged in multiple arc on the plan set forth in the patents of Woodward and Khotinsky, and had sought to secure economy in the working of such plants, you would not have endeavored so to distribute the total resistance of the entire circuit among the different parts thereof that the resistance at the points where the effective work was to be done, or, in other words, the resistance of the lamps themselves, would be high relatively to the resistance of the remaining parts of the circuit, 386
that is, to that of the generator and the conductors leading from the generator to the lamps?

> Objected to as irrelevant and incompetent; that what the witness thinks in 1889 he might have done in 1875 is not in any sense evidence in this case; that the question is not founded in the examination-in-chief.

A. As I understand the question, it seems to me prac- 387
tically identical with cross-questions 41 and 42; that is to say, it asks whether if I had been called upon in the years 1875 and 1876 to construct a Khotinsky or a Woodward plant, and had sought to secure economy in the working of such plant, I would not have made the lamps of high relative resistance.

The economy of any device, as I understand the matter, is the ratio of the output to the in-go. In an incandescent lamp, for example, the useful energy emitted is in the form of light and the energy consumed 388
is of course in the form of electrical energy. Light energy is measured in standard candles, and electrical energy is measured in watts; so that the economy of an incandescent lamp is the greater, the greater the amount of light produced by the expenditure of a given number of watts or the smaller the number of watts required to produce a given number of candles. The ratio of the watts expended in the lamp to the candles emitted by it (*i. e.*, the number of watts expended to

389 produce one candle light) is called the efficiency of the lamp.

If I were called upon to secure the maximum economy in the working of an incandescent light plant I should doubtless endeavor to produce the maximum amount of light for the minimum amount of electrical energy expended; and therefore, of course, for the minimum amount of mechanical energy expended upon the generator.

To secure this result would require the knowledge
390 of many more conditions and of many more deductions from laws than those which were known at the date of Khotinsky and Woodward, in my judgment. The amount of light given by the burner of an incandescent lamp, for example, does not depend upon its resistance alone, nor alone upon the current with which it is supplied. It is a function of the mass of the material, of its specific heat, of its radiating surface, of its specific radiating power, etc. The relations which should subsist between these quantities in order that the maxi-
391 mum of economy may be secured in the working of the plant were certainly not known at the date of Khotinsky and Woodward; for Mr. Preece tells us as late as 1879, in a quotation given in my 42d cross-answer, that,

> "We do not yet know the exact relation that exists between the production of heat and the emission of light with a given current. * * * The exact relations between current, heat, temperature, mass
392 and light have yet to be determined by experiment."

I see no reason, therefore, for modifying the statement with which I concluded the said 42d cross-answer, as follows:

> "So far, therefore, as I have been able to ascertain the state of the art at the date of Khotinsky and Woodward, I do not find that the knowledge of that day was sufficiently advanced to appreciate

> the advantages of high resistance in lamps used in 393
> multiple arc circuits. I conclude, therefore, that the knowledge would not have instructed me to make the resistance of the Khotinsky and Woodward lamps as high as practicable under the conditions of the question;"

and this, even in view of the fact that it may have been well known at that day as deductions from Kirchhoff's and Joule's laws, either that the current divides itself among the branches of a divided circuit in the inverse 394
ratio of the resistances, or that the amount of work done in two parts of the same circuit, other things being equal, is proportional to the resistance of those parts.

Adjourned for dinner.

395

Met at 8 P. M.

50 x-Q. I did not in the last question ask you whether, under the conditions named in said question, you would have made the resistance of the lamps "as high as practicable," but whether you would not have endeavored to make the resistance of the lamps "high *relatively to the remaining parts of the circuit.*" What do you answer to this precise question?

A. I do not see that there is any material difference 396
required in the answer under the assumption of the question. It seems to me that if I had had knowledge enough in 1875 to make "the resistance of the lamps high relatively to the remaining parts of the circuit," I should have had knowledge enough to have made that "resistance as high as practicable."

I repeat, therefore, the quotation from my forty-second cross-answer, as follows:

> "I conclude, therefore, that this knowledge

397 would not have instructed me to make the resistance of the Khotinsky and Woodward lamps high relatively to the remaining parts of the circuit."

51 x-Q. Do you mean then to assert or to leave the Court to infer, that under the conditions of the hypothesis contained in cross-question 49, you would have ignored the law of electrical distribution which, according to your answer to cross-question 47, was well known to you in 1875, and in the construction of the Wood-
398 ward and Khotinsky plants would have made the lamps of low resistance relatively to the remaining parts of the circuit?

A. By no means. I desire to have the Court understand distinctly that if I had been called upon to construct a Khotinsky or a Woodward plant at the date of those patents, I should not only not have ignored any of the well-known principles of electrical science, but I should have availed myself, I think, of all the knowledge of the day which would have enabled me "to se-
399 cure economy in the working of such plants." My position is simply that the knowledge of that day upon this subject, so far as I have been able to ascertain, was not sufficient to enable the advantages of high resistance in incandescent lamps to be so far understood and appreciated as to become a factor in their construction.

52 x-Q. Please state whether there was anything known to the world in 1875 and 1876, in regard to incandescent lamps, or whether there has been anything
400 discovered since those years which, if known in those years, would have led you to suppose, under the conditions of the hypothesis set forth in cross-question 49, that the general law of the distribution of electrical energy in the different parts of a circuit, which you have referred to in cross-question 47, would be inapplicable to electric lamps when arranged in multiple arc?

A. Of course it is well understood that in 1875 and 1876, the knowledge of the conditions determining the efficiency of incandescent lamps was insignificant.

It is also well understood that the progress which has 401
been made in these directions since that time has been very great. I have always supposed, however, that incandescent lamps even when arranged in multiple arc were amenable to the law of Joule.

It is stipulated by the counsel for the respective parties, that the complainants' time to close its testimony for its *prima facie* case be extended to include Saturday, November 2, 1889

Adjourned until Friday, the 1st of November next, at 402
10:30 A. M.

New York, November 1st, 1889.

Met pursuant to adjournment.

Present—Counsel as before, and the cross-examination of Professor Barker by Samuel A. Duncan, Esq., 403
defendant's counsel, proceeded as follows:

53 x-Q. Do you intend by the last part of your answer to have it understood that there was nothing known to you in the years 1875 or 1876 that would have led you to suppose, at that time, that incandescent lamps would not be amenable to Joule's law when arranged in multiple arc?

A. As I understand the question, I do.

54 x-Q. Was it not matter of common scientific 404
knowledge for many years prior to 1875 that the resistance of an electrical conductor, whatever its nature, would be increased by diminishing its cross-section?

A. It was, other things being equal.

55 x-Q. Was it not also matter of common scientific knowledge long prior to 1875 that the resistance of an electrical conductor, whatever its nature, would be increased by lengthening such conductor, its cross-section remaining constant?

A. It was, other things being equal.

405 56 x-Q. If in 1875 you had had occasion for any purpose to increase the resistance of an electrical conductor, the material composing such conductor remaining the same, in how many different ways might you have done this, with the knowledge that you then possessed?

A. I think that I might have varied the total resistance of the conductor either by varying its length or by varying its cross-section or by varying its specific resistance, the material remaining the same.

57 x-Q. If you had an incandescent lamp well
406 adapted practically to giving a light of sixteen candles, when run as a single light, or when arranged in a series, what change or changes would have to be made in the burner of such lamp in order to adapt it to practical use when arranged with other similar lamps in multiple arc?

A. It does not seem to me that I can answer the question without having the data of the circuits upon which the said lamp is to be used. As I understand the matter, if the conditions of the two circuits are
407 suitable, the same lamp may be used either in series with other similar lamps or in parallel with them.

58 x-Q. Do you then hold that the capacity which an incandescent lamp has of being used economically in series or in multiple arc, depends not upon the lamp itself, but upon conditions external to the lamp and pertaining to the circuit and generator?

A. That conclusion does not seem to me to follow from my last answer in which I intended simply to state that in my judgment the same lamp might be
408 used practically upon a series or a multiple arc circuit provided the conditions of the two circuits were suitable.

If, however, the question is intended to ask whether I do hold the position which it states, then I would say, that, as I understand the matter, the economy of an incandescent lamp depends not only upon its construction but also upon the amount of energy supplied to it and upon the form in which this energy is supplied; and these conditions are, I think, de-

termined by the character of the circuits, including the 409
generators, on which the said lamp is to be used.

59 x-Q. Given an incandescent lamp so organized that when introduced into a circuit in series it will give a light of sixteen candles when brought to incandescence, and can be run economically at this temperature, would it be possible to use such lamp economically when arranged in multiple arc, in large numbers?

A. I do not see any difficulty about it provided that the conditions of the circuits are suitable. In my 49th cross-answer I defined what I understood to be the 410
meaning of the term "economy" with reference to incandescent lamps; this economy, as then stated, being the ratio of the candle lights produced by a lamp to the watts expended to produce them. It seems to me that if this ratio is constant; that is, if the amount of light emitted by the lamp is constant and the amount of energy consumed by the lamp is also constant—the economy of the lamp will be constant.

Thus, for example, the lamp supposed in the question is stated to give a light of sixteen candles. Suppose 411
this lamp to have an efficiency of three watts per candle, or a total of forty-eight watts for the entire lamp. Suppose further, that to produce this total energy one hundred volts is required at the lamp terminals. The current through the lamp would evidently be forty-eight hundredths of an ampere. If, therefore, such a lamp be placed upon a circuit calculated to produce and to maintain a difference of one hundred volts between the terminals of the lamp, the current through the lamp would be forty-eight 412
hundredths of an ampere and the energy consumed in the lamp would be forty-eight watts as before. Provided, therefore, that the amount of energy supplied to the lamp be constant and provided this energy be supplied in the same form, I see no reason why the economy of the lamp should not be the same whether it be used in series with other lamps or in parallel with them.

60 x-Q. You have interpreted the word "economically" of my last question in a sense different from that

413 in which I used it. I intended the question to relate to the cost of generating and conveying to the lamps, when arranged in multiple arc, the current necessary to bring them up to the same candle power as when arranged in series. Instead of repeating the question in terms, I will put the matter in the following form:

If you were called upon to make a hundred incandescent lamps for use in series upon a single circuit and another hundred for use in multiple arc upon a single circuit, using the same material for the burners
414 of the lamps, would you make the burners of the two sets of lamps alike?

A. With the knowledge of the present day (which I understand is what the question assumes) I do not think that I should.

61 x-Q. What difference or differences would you make in the two sets of burners?

A. I think that I should make the burners of the lamps to be used on the multiple arc circuit of higher resistance than the burners of the lamps to be used
415 upon the series circuit.

62 x-Q. How much higher would you make the resistance of the multiple arc lamps and in what way would you effect this change of resistance?

Objected to by counsel for complainant as immaterial and irrelevant.

A. I would make the resistance of the multiple arc lamp as high as possible, and I would seek to secure
416 this high resistance:—1st, by selecting a material of high specific resistance; 2d, by selecting this material in the form in which it possessed the highest specific resistance; 3d, by diminishing the cross-section of the burner as far as practicable; and 4th, by increasing its length to as great an extent as was necessary to give the extent of radiating surface required consistent with the dimensions of the lamp.

63 x-Q. Suppose you used the same material in the multiple arc lamp as in the series lamp, that material also having the same specific resistance, could you se-

cure the requisite resistance simply by reducing the 417
cross-section of the burner from the dimensions of the series burner, without at the same time correspondingly increasing the length of the burner?

A. If the question is one of fact, then I suppose the answer to it would depend upon the meaning of the words "the requisite resistance"; and also upon the particular material employed for making the burner; since some materials are capable of being reduced in cross-section to a much greater extent than others.

If the resistance to be attained is the highest possi- 418
ble, then I think material of the highest specific resistance known would be employed; and this in a form in which its specific resistance is the highest. This substance is carbon in the form produced by the carbonization of a material the volatile portions of which pass off during the carbonization, leaving a porous carbon residue of high resistance.

Answer objected to as not responsive.

419

64 x-Q. Question repeated: with the explanation that the words "the requisite resistance" of the question are intended to indicate a resistance which will enable the lamp when arranged in multiple arc to give the same amount of light as when arranged in series?

A. The question as thus modified seems to me to involve many complex conditions. I think I may say generally, however, that in the case of platinum, for instance, the requisite resistance might be secured by sufficiently reducing the cross-section of the burner, 420
the length remaining unaltered.

65 x-Q. Does that answer assume that the lamp when used in multiple would be raised to the same temperature as when used in series?

A. It does not.

66 x-Q. Assuming the platinum to be brought to the same temperature in the two cases, please answer cross-question 64?

A. I do not think that it is possible to answer the question, the conditions being absolutely contradictory.

421 The amount of light emitted by any surface is a function of the extent of that surface, of the specific radiating power of the material used and of the temperature. By hypothesis the two burners are of the same length but one is of smaller cross section than the other. Hence the latter will have the smaller radiating surface. Evidently, therefore, if they give the same amount of light, as supposed in cross-question 64, the burner of smaller surface will have to be at a higher temperature, and, therefore, the two burners cannot be of the same
422 temperature. On the other hand, cross-question 66 requires the two burners to be brought to the same temperature. In which case, evidently, the burner having the larger radiating surface will obviously give the larger amount of light. It does not seem to be possible that the two burners can give the same amount of light, as they are required to do in cross-question 64, and at the same time be at the same temperature, as they are required to be in cross-question 66.

67 x-Q. If you sought to convert a series lamp such
423 as you would have made under the hypothesis of cross-question 60, into a lamp adapted for use in multiple arc, such as you would have made under the hypothesis of the same question, the material of the burner remaining the same, and the lamp to give the same amount of light when brought to the same temperature, could you do this by simply reducing the cross-section without correspondingly increasing the length?

A. As I pointed out in my last answer, it is impossible that both the hypotheses of the question; to wit,
424 that the same amount of light is given by the two burners and that the temperature of the two burners is the same, should be true, unless at the same time the radiating surface is the same for both. If the radiating surface of the two burners be assumed to be the same then it is a simple matter of geometry to prove that since the surface (supposing the burners to be of circular cross-section) is the product of the circumference by the length, the one of these factors cannot be varied without varying the other; since it is a well known mathematical principle that the product of two quanti-

ties being constant, these quantities, if they vary, must 425
vary inversely as each other.

Adjourned till Saturday the 2d inst., at 10½ A. M.

Saturday, November 2d, 1889.

Met pursuant to adjournment.

PRESENT:—Counsel as before and the cross-examination of PROFESSOR BARKER was continued, as follows: 426

68 x-Q. The term "filament" occurs frequently in the patent in suit. Please state whether this term as thus used derives its significance solely from the area of the cross-section of the carbon or burner to which it is applied, or solely from the length of the burner, or from these two elements combined?

A. The word "filament" I find is defined by Webster as "a thread or thread-like object or appendage; a fiber." I do not understand that the word as used 427
in the patent in suit, had yet acquired a technical meaning; and, therefore, I suppose it to be used in the sense in which it was ordinarily used at the time. In support of this opinion, I said in my examination-in-chief, that the term "carbon filament" was applied to the burner of an incandescent electric lamp for the first time in the history of the art in this patent.

I believe that the first use of the term "filament" occurs in the patent in suit, at line 85 of the first page; and from what precedes, it seems to me that the idea 428
of the word had occurred to the patentee, from the fact that he had used a "thread" of cotton properly carbonized as the burner of an incandescent lamp, and had found that when placed in a sealed glass bulb, properly exhausted, it offered a resistance to the passage of the current of from three to five hundred ohms. The use of the term "carbon filaments" is in connection with the material made by mixing tar and lampblack together to the consistency of thick putty, and rolling it out in the form of wire. He finds that the carbon fila-

429 ments thus made may be obtained "as small as seven one-thousandths of an inch in diameter, and over a foot in length." The only other use of the word "filament" in the specification (as distinguished from the claims), I believe, is in the 39th line of the second page, where "the ends of the carbon or filament" are represented as being secured to the leading wires by plastic carbonizable material. So far as the specification is concerned therefore, it seems to me that the term "carbon filament" is intended to refer to a carbon conductor of a
430 small or thread-like cross-section, and therefore does not derive its significance "solely from the length of the burner."

Moreover, as I have pointed out in my examination-in-chief, the material advantages of the lamp itself are advantages which flow solely from the fact that the filament has a small cross-section; these advantages, therefore, are entirely independent of the length of the filament.

The special advantage of length, as it seems to me,
431 is to be found in the fact that it enables a high total resistance to be given to the lamp; and this in its turn enables such lamps to be used upon a high potential circuit; a condition which results in economy of distribution.

For these reasons, taken in connection with what I said in my examination-in-chief, I am inclined to the opinion that so far as the lamp itself is concerned, the significance of the term "filament" lies solely in the small or thread-like nature of its cross-section; and
432 that so far as the use of the lamp upon a multiple-arc circuit is concerned, the term "filament" derives its significance solely from the length of the burner, other things being equal; it being understood that the material used is carbon of the same high specific resistance, which is the only substance referred to in the patent in suit of which the filaments are to be made.

69 x-Q. Directing your attention now to the first two claims of the patent in suit, is the term "filament" as used in those claims limited to a burner having a small cross-section, irrespective of its length; or does the

term as it appears in those two claims depend for its meaning upon the length to be given to the burner? 433

A. In my judgment the term "filament of carbon" of the first claim, and the term "carbon filament" of the second claim (the two terms, as I understand it being synonymous), refer to a carbon conductor or carbon burner of a cross-section sufficiently small to produce the important results which the patentee accomplishes, whatever its length.

70 x-Q. Do you mean to say that the "filament" of these claims is independent of the length that is given 434
to it, assuming, of course, that it has sufficient length to permit of its being securely attached to the leading-in wires?

A. That is my understanding of it.

71 x-Q. Is the filament of the second claim to be a filament of high resistance, as well as the filament of the first claim?

A. I do not find the term "filament of high resistance" to be used in the patent in suit. As I have already pointed out, the terms "filament of carbon" of 435
the first claim, and "carbon filament" of the second, refer to a carbon burner of a cross-section sufficiently small for the purposes indicated. The term "filament" seems to me to involve the idea of small cross-section and not the idea either of length or of resistance.

72 x-Q. Is this the difference, which, in your opinion, exists between the first and second claims of the patent, viz., that the first claim calls for a "filament" (that is, for a burner of small cross-section irrespective of its length) made from a particular kind of carbon, viz., a 436
"carbon of high resistance"; while the second claim calls for a "filament" (that is for a burner of small cross-section irrespective of its length) without regard to the specific resistance of the carbon composing it?

A. That is one of the differences between them. In my examination-in-chief I mentioned another difference, as follows:

"The limitations of making the filament of a particular kind of carbon and in a particular way

437 which appear in the first claim are not made features of the second claim."

73 x-Q. Then, as I understand, your opinion is that the specific resistance of the carbon has nothing to do with the second claim and that the mode of preparing the carbon which constitutes the burner has nothing to do with the second claim and that the length of the burner has nothing to do with the second claim. Is this your view?

438 A. My view is that the burner in the second claim, as in the first, should be made of carbon and would have, therefore, the specific resistance of the particular kind of carbon of which it is made. It is also my view that the filamentary form should be preserved in both cases.

The second claim seems to me to be broader than the first, so that I should say that if the burner is in the filamentary form and is made of carbon it would be the burner substantially of the second claim; and this
439 whether or not the said burner be "made as described" or whatever the actual specific resistance of the particular variety of carbon of which it is made. Moreover, it seems to me that the said burner would be the burner substantially of the second claim whatever its length; provided, of course, that this length be sufficient to enable it to perform its functions as a burner.

74 x-Q. How small in cross-section must the carbon be in order to be a "filament" within either of the first two claims?

440 A. It seems to me that the carbon filament should be of a sufficiently small cross-section to enable it to produce the important results indicated in the patent and pointed out in my examination-in-chief.

It should here be observed, I think, that practically a new art of electric lighting was created by the invention of the patent in suit. And that the differences between the older methods of obtaining light by incandescence in general and the new method, as well as the advantages of the latter, are pointed out in the patent itself. Among the advantages of using the carbon burner in the filamentary form

as enumerated in my examination-in-chief, are: the 441
use of a moderate current of electricity which permits the use of small leading-in wires of platinum; the obtaining of a small total radiating surface, of a small mass and therefore of a high resistance per unit of radiating surface; the elasticity and flexibility thus arising; the small amount of heat conducted back to the leading wires; and an effective electric contact between the leading wires and the carbon burner.

"I think this descriptive term finds its best definition in the results which the patentee accom- 442
plishes by the use of a carbon burner of relatively small cross-sectional area in place of the old carbon burners which the patentee speaks of as rods,"

as I said in my answer to the 5th direct question, referring to the term "carbon filaments."

If, however, the question is intended to ask how small in cross-section, in the absolute sense, the carbon must be made in order to be a filament, then I think that so far as the question is a legal one it is one to be 443
determined by the Court and not by the expert. In so far as it is a question of fact, I am not prepared to say: First, because the question is too general; and, second, because I know of no experimental data upon the subject which would enable me to form an opinion.

75 x-Q. Do you understand that a carbon burner, of any shape, adapted to "the use of a moderate current of electricity which permits the use of small leading-in wires of platinum," is a filament within the meaning of the first two claims of the patent? 444

A. I do not understand that the shape of the burner is material—first, because various shapes had been proposed for incandescent burners before the date of the patent; and, second, because it seems to me that the patent in suit itself contemplates the use of any suitable shape.

There is no doubt in my mind that one of the advantages of the filamentary form of carbon burner is that it enables the use of a "moderate current of electricity," and thus permits the use of small leading-in

445 wires of platinum. Whether conversely, in the absence of any other evidence, that which permitted the use of small leading-in wires and the use of a moderate current of electricity would necessarily be a filament—I cannot say in the absence of any other data.

Complainant's stipulated time extended by consent of defendant's counsel, hereby extended to and including November 9th inst.

446 Adjourned to meet at the Hotel Stratford on Wednesday, the 6th day of November inst.

HOTEL STRATFORD,
PHILADELPHIA, November 6, 1889.

Met pursuant to adjournment.

Present—Counsel as before, and the cross-examination of PROF. BARKER was continued by GENL. DUNCAN:
447

76 x-Q. What other data would you require before you could answer the question?

A. It seems to me that the question of volume, of the actual specific resistance, and of the degree of carbonization, are all important elements.

77 x-Q. Assuming the "volume" (I assume you mean by this term the volume of the burner), the actual "specific resistance," and the "degree of carbonization" to be those which are contemplated by the patent
448 in suit, how would you answer the question?

A. Then I should say that so far as I can now see such a burner would have a small or thread-like cross-section, and would therefore be a filament within the meaning of the said claims.

78 x-Q. But what I wish to know is, how small must the area of the cross-section of such a burner be in order to be a filament within the meaning of either the first or the second claim of the patent?

Objected to as already answered.

A. I do not see any material difference between this 449
question and cross-question 74, and I think I should answer it, therefore, substantially in the same way.

79 x-Q. Then I will ask you what you mean in your answer to cross-Q. 77 by the expression "a small or thread-like cross-section;" in other words, how small must be the area of the cross-section of the burner before the burner would have a small or thread-like cross-section as you used this term in the answer referred to?

450

Same objection.

A. I think that it should be made as small as is consistent with the methods of construction and with the required durability.

On the other hand, if the question is intended to ask what the limit is in the other direction, *i. e.*, how large the burner may be before it ceased to be a filament (or what seems to me to be quite the same thing essentially; how large the burner may be in order that it may have 451
"a small or thread-like cross-section"), then I think that the question is clearly one of degree and is therefore a legal one to be determined by the Court, as I have already stated. I do not feel myself competent to express an opinion as to the precise upper limit where a burner ceases to have a small or thread-like cross-section.

Relatively, however, as I have already pointed out, the patent in suit sets forth important advantages flowing from "a small or thread-like cross-section"; *i. e.*, 452
from a filamentary form given to the burner, and my judgment would be that a burner would be in a filamentary form and would therefore have "a small or thread-like cross-section," provided that these advantages were secured by its use.

80 x-Q. One of those advantages, as given by you in answering cross-Q. 74, is that it permits "the use of a moderate current of electricity which permits the use of small leading-in wires of platinum." I understand from your last answer that you would make the presence or

453 absence of this particular advantage one of the tests as to whether a particular burner is a filament, or, in other words, has what you have termed "a small or thread-like cross-section." I will now ask you what you mean by the term "moderate" as applied to the current in the quotation made from your former answer, and also how large the leading-in wires of platinum may be and still be "small," as you have used this term in the quotation made?

A. The word "moderate" as used in my 74th cross-
454 answer and in my examination-in-chief is also used in a relative sense. In my direct examination I quoted from the patent in suit certain passages, in which the old lamps were contrasted with the lamp of the patentee. The current required for the latter lamp is a "moderate" current compared with the current required by the former. And of course the leading-in wires must be as "small" as is consistent with their carrying this current into the lamp without undue heating.

81 x-Q. What do you mean when you say that one
455 current is "moderate" as compared with another?

A. I think the word is here used in its ordinary sense. As I understand it, one thing is said to be "moderate" in a certain direction as compared with another when it is not extreme in that direction as compared with this other. It seems to me that one current is "moderate" as compared with another whenever it is not extreme as compared with that other.

82 x-Q. What was the current that was required with the lamps with which you say the lamp of the Edison
456 patent is contrasted, and wherein and to what extent does the "current required for the latter lamp" differ from such former current?

A. The patent in suit states that the burners of the old lamps previously experimented with were "rods of carbon of one to four ohms resistance." The question being a general one, I infer that I may assume in answering it data concerning these old lamps which seem to me fair; there being quite a variety of these old lamps known. My judgment is that the efficiency of these old lamps was low, say about ten watts per candle

as a minimum. Moreover, these lamps did not give a 457
moderate candle power, such, for example, as that of the ordinary incandescent lamps of the present day or that of an ordinary gas jet. So that I think we may suppose fifty candles to be a minimum for them in this direction. This would give a total expenditure for the lamp of five hundred watts and a current strength of twenty-four amperes.

On the other hand, I find from the defendants' admission in evidence herein that the current required for
the operation of the defendants' lamps put in evidence 458
as exhibits in this case varies between 0.55 and 1.1 amperes. An Edison lamp of the ordinary construction requires, I believe, from 0.45 to 0.5 ampere.

83 x-Q. Why, in your last answer, do you assume the old lamps to have been of not less than fifty candle power and why do you assume their efficiency as ten watts per candle?

A. For two reasons. In the first place the burners of these lamps were "rods" of carbon of low resist-
ance, and were therefore of considerable cross-section 459
and considerable mass. To heat such carbons up to a light-giving incandescence would require, as it seems to me, a large expenditure of energy; so that even the economy of ten watts per candle stated in my last answer could not be secured unless the amount of light given by the lamp was considerable, say from fifty candles upwards.

In the second place, those of the old lamps which I have seen in operation and those, so far as I remember,
the operation of which I have seen described in the 460
literature of the subject, did as a matter of fact give a light of approximately one hundred candles. From the resistance of the lamp and the current strength it employs the watts per candle may of course be calculated.

84 x-Q. I conclude from your last two answers that when you speak of one current as being moderate in comparison with another one, you refer to the relative number of amperes. Does this correctly state your view?

A. I intended to be so understood.

461 85 x-Q. What is the largest current, stated in amperes, which you would regard as a "moderate" current?

A. That depends, as it seems to me, upon the purpose for which the current is to be used. I should regard a tenth of an ampere as a moderate current for some purposes and a hundred amperes as a moderate current for other purposes. Relatively the current of a tenth of an ampere might be moderately large and the current of a hundred amperes moderately small;
462 depending upon the standard used for comparison.

86 x-Q. I did not in my last question call your attention in terms to incandescent electric lamps because I presumed that you would assume from the context that the question was directed to currents to be used with such lamps. Will you please answer the question under this assumption?

A. That again seems to me to be a question of degree. The "moderate current" referred to in my direct examination is that current, small in amount,
463 which is sufficient to raise the filamentary carbon burner to an economical light-giving incandescence; which moderate current permits the use of small platinum leading-in wires.

What the absolute current strength in amperes may be as a maximum; or, in other words, what the maximum amount of current is in amperes which may be used in an incandescent lamp commercially I do not know as a matter of fact. Opinions on this subject differ very widely and I am not in possession of ex-
464 perimental data as to the continued relation between the economy and the current required to enable me to answer the question.

87 x-Q. Can you give any better or more exact definition of the term "moderate current" than that it is a "current which is sufficient to raise the filamentary "carbon burner to an economical light-giving incandes-"cence?"

A. I do not think that I can better express the idea which I had in mind when I used the term "moderate current" in my examination-in-chief than by saying

that it is the current which is sufficient to raise the fila- 465
mentary carbon burner of that patent to an economical light-giving incandescence; in comparison with the current required to operate the old lamps.

There is no doubt in my mind that a current of about an ampere, the current required to raise the filamentary carbon burner of the defendant's lamp, for example, to an economical light-giving incandescence, is a moderate current in comparison with the current of twenty-four amperes required to maintain some of
the old lamps. But where a line is to be drawn in this 466
direction I do not feel competent to say.

88 x-Q. Then I suppose a current of ten amperes might under some circumstances be regarded as a moderate current, even in connection with incandescent lamps provided with carbon burners?

A. As I have just said, I do not of course know where the Court would draw the line. In endeavoring to answer the question to the best of my ability, I can only say that my private judgment leads me to think
that a current of ten amperes would not be a moderate 467
current when used with one of the incandescent lamps in ordinary use. Moreover, I have never known a current as high as ten amperes to be used commercially with incandescent lamps of the modern type.

89 x-Q. Would a current of five amperes be a "moderate" current for incandescent lamps?

A. That I do not know. I have no means of forming an opinion.

90 x-Q. Would a current of two amperes be a "mod-
erate" current for incandescent lamps? 468

A. That I do not know, but I should think that possibly it might.

91 x-Q. The patent in suit gives as one reason why an incandescent lamp of four ohms resistance cannot be worked in great numbers in multiple arc, that such a lamp would require "main conductors of enormous dimensions."

Would this be true, even if the lamp globe were made "entirely of glass," and were highly exhausted?

A. As I understand the question, I think that it would

469 substantially, other things being equal; always remembering, however, that the incandescent lamp referred to in the patent in suit has a carbon rod for its burner, and that more current is required to maintain incandescence in a receiver or globe not exhausted, than in a globe which is exhausted; and always assuming that it is possible to construct such a lamp globe entirely of glass.

92 x-Q. Then, would a lamp consisting of a carbon of four ohms resistance, hermetically enclosed in a globe
470 "made entirely of glass" and highly exhausted, be within the claims of the patent in suit?

A. It is my judgment that the said lamp if it consisted of the combination of a carbon filament with a receiver made entirely of glass and conductors passing through the glass, from which receiver the air is exhausted; and further, if the carbon of which the filament is made is carbon of high specific resistance and if it is made by giving it its filamentary form before carbonization, the said lamp would be within the
471 claims of the patent even if its resistance was four ohms.

Adjourned at 6 P. M. for dinner.

Resumed at 8 P. M.

93 x-Q. Could the lamp of the last question be worked in great numbers in multiple arc without
472 the employment of main conductors of enormous dimensions?

A. Certainly; since the current required to maintain the filamentary burner at the same incandescence is the same, whatever its length.

94 x-Q. Why, then, could not the burners of the old lamps spoken of in the patent in suit, having a resistance of four ohms, be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions?

A. As I understand the matter, it is because the

burners of the old lamps were "rods of carbon" of 473
relatively large cross section, the carbon itself having a low specific resistance. Hence such a burner would require a large volume of current to develop in it the necessary incandescence.

95 x-Q. What do you mean by the two words "relatively" and "low" in the last answer; do you mean that the so-called "rods" had a large cross-section relatively to the "filaments" of the patent in suit and that their specific resistance was low relatively to that of the filaments of the patent? 474

A. What I had in mind was that the "rods of carbon" which constituted the burners of these old lamps were of large cross-section relatively to the purpose for which they were intended, *i. e.*, for giving light by incandescence. I had in mind, too, the fact that the particular variety of carbon of which these rod burners were made was compact and dense and therefore had a lower specific resistence than that of other and more porous varieties of carbon.

If the question calls for the direct comparison it is 475
my judgment that the "rods of carbon" are also of large cross-section relatively to the filaments which constitute the burners of the lamps of the patent in suit; and further that the specific resistance of the carbon of which the "rods" are made is lower than that of the carbon constituting the filament of the patent when made by the process of carbonization.

96 x-Q. Now, please tell us how much larger in cross-section these carbons of the old lamps were than is the carbon of the patent in suit and how much lower their 476
specific resistance was?

A. I think it may be quite possible in many cases to form an opinion that one body has a larger cross-section than another or is more porous than another without making any exact measurements to determine the exact numerical relations existing. This is the fact in the present case. I have no numerical data which will enable me to give the ratio of the specific resistances of porous and non-porous carbon, although it would seem to be obvious that the specific resistance of a

477 porous carbon would be higher than that of a non-porous one. From data at hand, however, I think I may say that the rods of some of the old lamps had a cross-section fifty times as great as that of the filament of the lamps of the patent in suit.

97 x-Q. What data have you at hand that justifies this statement of the relative cross-section of the burners of the old lamps and the burner of the lamp of the patent in suit?

A. The patent in suit states that the carbon filaments
478 made by a combination of lamp-black and tar may be rolled out in the form of wire as small as seven-one-thousandths of an inch in diameter. Since carbonizing would reduce this diameter to five and perhaps to four-one-thousandths of an inch, the carbonized filament thus resulting would evidently have a cross-section of twenty millionths of a square inch, very nearly. The same cross-section substantially is to be found in the Edison lamps at present in use.

On the other hand, the rods of carbon used in some
479 of the old lamps had a diameter of a millimetre. I have seen rods of this size used in these lamps, but I have never seen smaller ones so used. Such a rod evidently would have a cross-section of twelve hundred and fifty millionths of a square inch, about, whence it follows, I think, that since twelve hundred and fifty millionths is more than sixty times twenty millionths, the cross-section of the rods of some of the old lamps was at least fifty times as great as that of the filaments of the lamps of the patent in suit as my last answer
480 stated.

Adjourned till Friday, the 8th inst., at 10½ A. M. to meet at the office of Mr. Seward, 31 Nassau street, New York.

NEW YORK, November 8th, 1889. 481

Met pursuant to adjournment.

Present—Counsel as before, and the cross-examination of PROFESSOR BARKER by GEN. DUNCAN, was continued as follows:

98 x-Q. In making the comparison called for by the last question I will assume (without knowing such to be the fact) that you selected an Edison burner which has a cross-section of very much smaller area than that of the largest burner that would embody the invention 482
to which the patent relates. I will now ask you, how much larger in cross-section the carbons of the old lamps were than is the largest carbon that would embody the invention of the Edison patent?

A. Of course, if I knew what the cross-section is of the largest carbon that would embody the invention of the patent in suit, it would be simply a matter of calculation to determine how much larger than this cross-section the carbons are which were used in the old lamps. I do not regard this question, therefore, as 483
materially different from 74 x-Q. and 79 x-Q.; since, as it seems to me, the carbon burner of the Edison lamp must be a filament, *i. e.*, must have a small or thread-like cross-section. I cannot answer the question, consequently, better than by repeating what I have before said, that "I do not feel myself competent to express an opinion as to the precise upper limit where a burner ceases to have a small or thread-like cross-section."

99 x-Q. Do you intend by anything that you have heretofore said to be understood, or do you in fact 484
hold that you do not know and cannot state how much higher the specific resistance of the burner of the patent in suit is than that of the burners of the old lamps referred to in the patent?

A. I think that I stated my position on this subject in my 96th cross-answer, as follows:

"I have no numerical data which will enable me to give the ratio of the specific resistances of porous and non-porous carbon, although it would

485 seem to be obvious that the specific resistance of a porous carbon would be higher than that of a non-porous one."

The specific resistance of carbon depends, as is well known, upon its state of aggregation; and therefore is different, not only for different kinds of carbon, but for the same kind of carbon, frequently, under different conditions.

The specific resistance of the carbon of the burner of such an incandescent lamp as is described in the patent
486 in suit would undoubtedly be high, as it seems to me, since it is made in a way calculated to make it porous; *i. e.*, by the carbonization of a material the volatile portions of which pass off during the carbonization leaving a porous mass. The specific resistance of the carbon of the burners of the old lamps, on the contrary, would undoubtedly be low, since it is made by a process calculated to consolidate it and to make it dense and compact; and thus to diminish its resistance.

487 That the carbon produced by these two processes properly carried out would differ widely in its specific resistance I have no doubt, but I have no idea where the dividing line would be drawn in the absolute sense between a high and a low specific resistance.

If the question calls for a numerical statement as to the relative specific resistance of two varieties of carbon, one made by the process of the patent in suit, to wit, the carbonization of a material the volatile portions of which pass off during the carbonization; and
488 the other made by a process calculated to give to the carbon the greatest possible density, then I can only say, that so far as I know, the data which would enable me to answer it are wanting; first, in the general sense, since very few experiments have been made upon the subject, and the reliability of the results cannot be guaranteed; and second, in any particular instance, because the particular specific resistance of the two specimens of carbon to be compared would require to be determined each by itself.

100 x-Q. Does not every process of carbonization, those that were known before the date of the patent in suit as well as the process contemplated by the patent, 489
involve the driving off of the volatile portions of the substance carbonized?

A. The process of carbonization, as I understand it, consists in the production of carbon from materials containing it, by driving off by heat the volatile portions.

101 x-Q. What is your authority for holding (as I understand you do), that the carbons of the patent in suit are necessarily more porous, and therefore of higher specific resistance than the carbons that had 490
been used in the old incandescent lamps, referred to in the patent?

A. I think that I find sufficient authority for my opinion in the patent in suit itself. The first claim speaks of "a filament of carbon of high resistance made as described." As I understand it, this means that the burner is to be made by giving to the material the filamentary form and subsequently carbonizing it. All the materials mentioned in the patent, I believe, as materials used for making the burner, are materials the volatile 491
portions of which pass off during carbonization; so that the only kind of carbon contemplated by the patent itself is the porous carbon—the carbon of high resistance—thence resulting.

On the other hand, the patent speaks of "rods of carbon of one to four ohms resistance," as the form which was given to the burners of the old lamps. Since I know that at least in some of the old lamps answering to the description of them which is given in the patent, the "rods of carbon" were made by a process calcu- 492
lated to consolidate the carbon and to make it dense and compact, I expressed the opinion that the carbon constituting the burners of the old lamps was in general denser and of a lower specific resistance than the carbon of the patent in suit produced by the carbonization there described.

102 x-Q. Do you mean by this last answer to intimate that the carbons of the old lamps were not made, or at least that some of them were not made, by the process of carbonization?

493 A. I suppose that in a certain sense it is true in gen-
eral that all carbon is produced by the process of car-
bonization. But I do not understand that the word
"carbonization," if used at all, with reference to the
process by which the "rods" of the burners of some of
the old lamps were made, would be used in the same
sense as that in which it is used with reference to the
carbon of the filamentary burner of the patent in suit.
The one process produces, or is intended to produce, a
carbon of the maximum compactness and the minimum
494 specific resistance; while the other process produces,
or is intended to produce, a carbon of the maximum
porosity consistent with durability and therefore of the
maximum specific resistance.

103 x-Q. Wherein does the process spoken of in the
patent as "carbonization" differ from the processes of
carbonization that were known and practiced prior to
the patent?

A. I do not understand that the process spoken of
in the patent in suit as carbonization is materially dif-
495 ferent from processes which were known and practiced
prior to the date of the patent.

104 x-Q. Then why would not the old processes have
made the carbons as porous as you assume the carbon
of the patent to be?

A. As I view the matter there appears to be some
ambiguity in the use of the term "the old processes."
It would appear to be evident that the product of a
process of carbonization proper, this process being per-
formed in the same way and upon the same material,
496 should be essentially the same, other things being equal,
whatever the date of the experiment. I suppose that
a piece of wood, for example, carbonized in a closed
chamber by subjecting it to a high heat would be
equally porous whether carbonized in 1875 or in 1885.

In previous answers I have referred to the process
by which the burners of the old lamps were made. If
the expression "the old processes" refers to processes
such as this, then it seems to me that the reason why they
would not have made carbons as porous as those of the
patent is to be found in the fact that the carbons thus

made were specially treated so as to make them dense 497
and compact and not porous.

105 x-Q. What was the treatment to which you refer
and which you say distinguished the old carbons as to
porosity from those of the patent?

A. My recollection is that the treatment consisted in
repeatedly immersing the carbons in a solution of sugar
or other equivalent solution and rebaking; this opera-
tion being continued till the necessary compactness and
density was obtained.

106 x-Q. In that operation was not the sugar always 498
decomposed and the volatile portions driven off?

A. I suppose that it was.

107 x-Q. And did not that leave a carbon residue
which was porous?

A. The mass resulting from the carbonization of
sugar is of course a porous one; but inasmuch as the
process was operated to produce, and did, in fact, pro-
duce, a denser and less porous carbon, taken as a
whole, it does not seem to me that it would be proper
to say that this treatment with sugar solution rendered 499
the carbons to which it was applied more porous as a
whole.

108 x-Q. I do not ask you whether the carbons pro-
duced by the sugar treatment were more porous after
such treatment than before, but whether the resultant
carbon residue was not a porous structure?

A. Supposing the words "the resultant carbon resi-
due" to refer to the carbon residue produced by the
carbonization of the sugar alone, then I should say that
this residue *per se* is a porous one. 500

109 x-Q. Wherein then did such carbons differ from
the carbon of the patent so far as concerns specific re-
sistance?

A. I do not think that I can give a better answer to
the question than I have already done. The carbons
of the old lamps were made as dense as possible in the
first place and then were consolidated and made still
less porous by the subsequent treatment above men-
tioned. The carbon filaments of the patent in suit are
made by a process calculated to give to the carbon as

501 high a porosity and as low a density as possible consistent with durability. Hence, as I said in cross-answer 102:

> "The one process produces or is intended to produce a carbon of maximum compactness and a minimum specific resistance, while the other process produces or is intended to produce a carbon of the maximum porosity consistent with durability, and therefore, of the maximum specific resistance."

502 110 x-Q. To whose process as applied to the old carbons do you refer when you say that "they were made as dense as possible in the first place," and were consolidated by subsequent treatment?

A. I do not remember to have had the process of any particular individual in mind. The process in general is, I believe, the process by which carbons for arc lighting have long been made; and in arc lighting it is desirable to have the carbon of as low specific
503 resistance as possible. The process of treatment above mentioned is, I believe, substantially that of Carré, a maker who has produced the "rods of carbon" used in some of the older lamps.

111 x-Q. Is it not a fact that Carré, as well as others, in making carbons for electric lamps, manufactured them by mixing pulverized charcoal with either tar or sugar or other carbonizable material, then moulding the plastic compound to shape and then carbonizing it?

504 A. Arc-light carbons are made in general, I believe, by mixing some suitable variety of carbon with tar or other suitable substance, and by forcing the resulting mass through a die; the rods thus formed being afterward baked. I do not know that Carré used charcoal; although he did consolidate his carbons, I believe, by subsequent repeated treatment. I think, however, charcoal has been used for the purpose. But I have known of the use of gas retort carbon, the carbon deposited from natural gas and even anthracite, the three forms of carbon possessing the highest density.

112 x-Q. What do you find in the patent that justifies your statement in answer to cross-question 109 505
that "the carbon filaments of the patent in suit are made by a process calculated to give to the carbon as high a porosity and as low a density as possible consistent with durability?"

A. The quotation in the question taken from my answer to the 109th cross-question I understand to express simply my opinion that the process by which the carbon filaments of the patent are made is a process calculated to give to the carbon a high porosity and 506
consequently a low density and high specific resistance; the latter two following from the former.

With reference to the patent, the first claim speaks of a "filament of carbon of high resistance" which, as I have before said, I understand to mean carbon of high specific resistance. Such carbon would be produced by the process of the patent, as a matter of fact; to wit, the carbonizing of cotton and linen thread, wood splints, papers, etc., as well as the carbon in various forms mixed with tar. Indeed, the form of carbon 507
thus produced, necessarily porous, is the only form of carbon which the patent itself mentions as suitable for the purpose. The specification enumerates as an advantage of using a carbon wire of such high resistance that fine platinum wires may be used for leading wires; which high resistance I understand to be high specific resistance since it involves the construction only of the lamp itself. Since the patent requires the filament to have a high specific resistance and since the advantages thence arising would be increased by increasing the 508
specific resistance, other things being equal, it seems to me that the patent itself warrants the opinion that the process of the patent is calculated to secure this end to as great a degree as possible consistent with the conditions in other directions.

Adjourned till Saturday the 9th instant, at 10½ A. M.

509 SATURDAY, November 9th, 1889.

Met pursuant to adjournment.

Present—Counsel as before, and the cross-examination of PROFESSOR BARKER by GEN. DUNCAN proceeded as follows:

113 x-Q. In your testimony hitherto, particularly your last few answers, you have laid special emphasis on the high degree of porosity and consequent high specific resistance, which you assume characterizes the
510 carbon burner of the patent in suit, as distinguished from the carbon burners of the older lamps referred to in the patent. I now ask you whether a lamp having as its burner a filament of carbon having a specific resistance not higher than that of the carbons of the old lamps thus referred to, such burner being also enclosed in an exhausted globe made entirely of glass, would embody the invention which is described in the patent and covered by either of the first two claims thereof?

511 A. It is my judgment that such a lamp would undoubtedly embody the invention which is described in the second claim of the patent in suit. I said in my direct examination with reference to the second claim that:

> "The limitations of making a filament of a particular kind of carbon and in a particular way which appear in the first claim are not made features of the second claim."

512 Consequently, as I said in my 73d cross-answer:

> "The second claim seems to me to be broader than the first so that I should say that if the burner is in the filamentary form and is made of carbon it would be the burner substantially of the second claim; and this whether or not the said burner be 'made as described' or whatever the actual specific resistance of the particular variety of carbon of which it is made."

In reference to the first claim I think that if the

burner were in the filamentary form and were made as 513
described, such a lamp, other things being equal, would be covered by the said claim even if the specific resistance attained by the process of carbonization as described in the patent should happen to be not higher than that of some of the carbons made for arc-lighting. As I have already pointed out, the two processes of producing carbons are intended to produce results as widely different as possible; the one securing the maximum density and the minimum specific resistance, and the other a minimum density and the 514
maximum specific resistance. It seems to me that both these processes might result, by varying the materials used and the details of the process itself, in the production of a carbon of approximately the same specific resistance. If such a carbon made by the process referred to in the patent were used for the filament it would attain in my judgment the material advantages set forth in the patent in suit, though of course, in a less degree in proportion as the carbon itself had a lower specific resistance. How 515
low this specific resistance must be before the carbon can be said to cease to be "carbon of high resistance," I cannot say; first, because the question seems to me to be determinable only by the Court on its legal side, and second, because I have not considered the question.

114 x-Q. In the last division of your answer you have assumed that my question was comparing the specific resistance of the burner of the patent with that of carbons which had previously been made for *arc*- 516
lighting. In fact, my question instituted a comparison between the carbon of the patent and the carbons of the old lamps which were referred to in the patent and which were *incandescent* lamps. I now ask you anew whether a lamp having as its burner a filament of carbon of a specific resistance not higher than that of the carbons of the old incandescent lamps referred to in the patent in suit, such burner being also enclosed in an exhausted globe made entirely of glass, would em-

517 body the invention covered by the first claim of the patent?

A. A general question seems to me to require only a general answer. I thought that I had pointed out in previous answers that the "carbons which had previously been made for arc lighting" were the carbons used in the old lamps referred to in the patent; or at least in some of them; since I said in my 110th cross-answer, referring to the process of making the carbons for the old lamps:

518 "The process in general is, I believe, the process by which carbons for arc lighting have long been made; and in arc lighting it is desirable to have the carbon of as low specific resistance as possible."

If, therefore, the carbon of which the rods used in arc lighting were made be the same as that of which the rods used in some of the older lamps were made, and therefore had the same specific resistance, it seems
518 to me that I should answer this question in the same way as I did the last one substantially.

115 x-Q. From this I understand your view to be that it is not necessary for the carbon composing the filament of the first claim of the patent in suit to have a higher specific resistance than that of the carbons of the old incandescent lamps referred to in the patent. Is such your view?

A. It is certainly not my view that it is necessary for the carbon composing the filament of the first claim
520 of the patent in suit to have a higher specific resistance than that of the carbons of any of the older incandescent lamps. Because, as I have already stated, even the process of making carbons for arc lighting (which carbons of smaller size but of the same specific resistance, were used in some of these old lamps) might result in the production of a carbon as porous as the carbon resulting from carbonization, provided the two processes were worked with reference to this end. And, second, because my recollection is that rods of charcoal, produced of course, by the ordinary process

of carbonization, were also used in some of these older 521
lamps.

116 x-Q. Then, as I understand you, a high specific resistance, in the sense of a specific resistance higher than that of the carbons used in the old incandescent lamps referred to in the patent in suit, is not a feature essential to the invention covered by the first claim of the patent. Is this your view?

A. It is my view that the filament of carbon of the first claim should be a filament of carbon of high specific resistance. But I do not understand that this re- 522
sistance is necessarily higher than that of any of the carbons used in the older incandescent lamps.

117 x-Q. Is it necessary in order to bring the filament within the first claim of the patent, that the specific resistance of the carbon composing it should be higher than that of the carbon composing the pencils that had previously been used in *arc* lighting?

A. I understand it to be desirable that the pencils of carbon used in arc lighting should have as low a specific resistance as possible; and I understand further that 523
the processes by which these carbons made for arc lighting are manufactured, are such as to make the density as great and the specific resistance as low as is practically attainable. While, therefore, the arc light carbons, as made by different makers, may vary considerably in their specific resistance, I think that I should characterize them in general as carbons of low specific resistance. If, therefore, the filament of carbon of the first claim were a filament of carbon of low resistance (meaning by this, of the low specific resistance 524
possessed by the best examples of the carbons employed for arc lighting), I do not think that such a filament would be within the first claim of the patent.

118 x-Q. Assume a filament made of carbon of the same specific resistance as that of the average commercial carbon pencils used in arc lighting, prior to the patent in suit, and assume such filament to be enclosed in an exhausted globe, made entirely of glass, with proper leading-in wires; would such a lamp be within the first claim of the patent?

525 A. My impression is that the "commercial carbon pencils used in arc lighting prior to the patent" varied very considerably in their specific resistance and I do not know, therefore, what to assume as to the "average" value of these carbons in this respect. If we may assume what seems to me to follow from the meaning of the word itself: to wit, that the average specific resistance was higher than the lowest specific resistance and so much higher, that these average carbons may be spoken of as carbons of high specific resistance
526 as compared with the lowest, then it seems to me possible that a filament of this carbon, made as described, would be such a filament of carbon of high resistance as is contemplated in the first claim, other things being equal. If, however, we must assume that the average commercial carbon pencils were of low specific resistance, then I think that such a filament of carbon of low resistance would not be within the first claim of the patent. In other words, I mean to say that a filament of carbon of unmistakably low resistance, such as I un-
527 derstand the carbon to have been which was used in some of the arc lamps employed before the date of the patent, would not have been the material of the filament contemplated in the first claim, as I understand it.

119 x-Q. What I wish to know is this: whether in your opinion it is essential to the filament of the first claim of the patent in suit that it be made of carbon having a higher specific resistance than that of the carbons previously in use for arc lighting. Please give as
528 direct an answer to this question as you can?

Objected to as already answered.

A. I do not think that I can answer the question better than by saying that in my opinion it is essential that the filament of carbon of high resistance of the first claim be made of carbon having a higher specific resistance than that of some of the carbons previously in use for arc lighting.

Adjourned till Friday, the 15th inst., to meet at Mr. Seward's office at 10½ A. M. of that day.

New York, November 15, 1889. 529

Met pursuant to adjournment.

Present—Counsel as before, and the cross-examination of Professor Barker by Gen. Duncan continued as follows:

120 x-Q. In your opinion is it also essential to the first claim of the patent that the filament be made of a carbon having a higher specific resistance than that of all of the carbons previously in use for arc lighting?

A. That I should hardly like to say; since carbons 530
may have been used for arc lighting which, owing to the process by which they were made, had a specific resistance equal perhaps to that obtained in some cases by the process of carbonization.

121 x-Q. I understand you to have said heretofore in substance that the specific resistance of the carbons in use commercially for arc lighting prior to the date of the patent in suit was substantially the same as that of the carbons used for incandescent lighting prior to said date. Is that your understanding of the matter? 531

A. I understand that some of the "rods of carbon" of which the patent in suit speaks as used in the old incandescent lamps were made by Carré, of Paris, by the same process substantially as that by which the carbons of larger diameter were made, which in general were used for arc lighting.

If this be so, then I see no reason why these smaller carbons should not have approximately the same specific resistance as the larger ones, since they were made in substantially the same way and of the same 532
materials.

122 x-Q. How would the specific resistance of the Carré carbons to which you refer compare with the specific resistance of the carbons made of tar and lamp black by the process set forth in the patent in suit?

A. I should suppose that the process of the patent in suit, which is referred to in the question, would produce a carbon filament of higher specific resistance than that of the Carré carbons.

533 123 x-Q. Why?

A. Because the object of the patent in suit is to obtain a porous carbon, while the object of Carré, as I understand it, is to obtain a dense one.

The respective processes would therefore be worked to secure these ends, as it seems to me.

124 x-Q. What would be the difference in the working of the processes whereby, as you think, different products would result?

A. I think that the quality of the materials em-
534 ployed, as well as the proportions in which they are united, would materially influence the result. Moreover, as I have already pointed out, the carbons in the Carré process are consolidated by subsequent successive treatments.

125 x-Q. I will now call your attention to a portion of your deposition given during the present year in the suit of the Consolidated Electric Light Co. against the McKeesport Electric Light Co., in the U. S. Circuit Court for the District of Pennsylvania, such portion
535 being questions and answers 49 and 50, as follows:

"49 Q. Have you read and do you understand French Letters Patent No. 113,706, of July 12, 1876, issued to Octave Gauduin, and the certificates of addition thereto, dated April 7, 1877, and June 12, 1877, respectively. If so, please describe such matters contained therein as in your opinion are more particularly material to the questions herein at issue?

536 "A. I have read the said letters patent and the certificates of addition thereto, and believe that I understand them.

"I find that the object of the invention which is set forth in the original patent is the production of various physical and chemical articles such as crucibles, pencils for producing the electric light, etc., which the patent states should be made of chemically pure carbon. This object the inventor obtains by decomposing in close vessels various carbonaceous materials, such as tar, resins, bitumens, and the like, thus producing a very pure

coke, which is mixed after pulverization with tar, 537
pitch or similar material to a plastic mass, and is then forced through a die, thus forming said pencils for the electric light, which are subsequently carbonized at a high temperature.

"The first certificate of addition describes a modification of this process which enables the inventor to give to the carbon the definite form in which it is desired to preserve it, and which simplifies considerably the manufacture. The process here described consists substantially in shap- 538
ing the crucibles, vases and pencils for electric light or electro-chemical purposes, etc., out of dry and properly selected wood by any method suitable to be used in working wood. The object thus shaped in wood is then converted into a hard and compact carbon, preserving the original form by suitably drying it, impregnating it with tar, bitumen, sugar, caramel, etc., and heating it at first slowly, and finally to a high temperature in a reducing atmosphere. To especially purify the 539
carbon the inventor treats it during the intermediate state with acids, alkalis, etc. He further states that he has also manufactured articles in carbon with cotton, hemp, linen and cellulose, impregnated in the same way with tar or other similar material, and shaped in such a way as to give to it the form desired, treating it subsequently in the same way as in the case of the wood already mentioned.

"In the second certificate of addition dated 540
June 12, 1877, Gauduin describes the particular form of tubular furnace by means of which the said crucibles, electric light pencils, etc., can be baked continuously at a high temperature.

"50 Q. In view of the Gauduin patent, and in particular in view of the certificate of addition of April 7, 1877, have you any further statement to add to your previous direct testimony as to the novelty of the use of a vegetable fibrous carbon or a vegetable textile carbon as an incandescent con-

541 ductor for an electric lamp, prior to the year 1878?

"A. It seems to me that we have described in said certificate of addition electric light conductors, produced by forming the material to be carbonized, to wit, vegetable fibrous material in the form of of wood to the desired shape and size, and then carbonizing it in closed vessels. It seems to me further, that we have described the manufacture of objects in carbon, by carbonizing various forms of
542 textile material, such as cotton, hemp, linen and cellulose of any desired kind shaped in the form desired, by mixing it with tar or other similar material, and then carbonizing it.

"The patent itself does not state specifically whether the said carbon pencils are to be used for arc or for incandescent lighting, but inasmuch as both forms of lighting were well known in the art at the time, I see no reason for supposing that the inventor intended to restrict their use to either of
543 these modes of lighting. Indeed, to my knowledge the said Gauduin pencils were made of various sizes within a considerable range; some of them being not over a millimetre or two in diameter as I recollect them, and, therefore, adapted only to the production of light by incandescence.

"Further, it does not seem to me to have required invention, in view of the state of the art in 1878, to substitute the carbon conductor thus made by the Gauduin process from vegetable fibrous
544 material put into the desired shape before carbonization, for the straight or curved pencils of mineral carbon which had been already used in incandescent lamps to which I have already referred: such, for example, as that of Kosloff and Konn; or that it would have required invention at that date to substitute the said Gauduin pencils for the pencils of mineral carbon described by the patentees of the patent in suit, as used in their prior patents already referred to in this case."

Please state whether, in your opinion, the specific re-

sistance of the Gauduin carbons, manufactured in the 545
manner thus described by you, would be materially different from that of the carbons made out of tar and lamp black, as described in the patent in suit?

A. That would depend, it seems to me, upon the materials employed in the two cases and upon the way in which the two processes were worked. It will be observed that the method for producing the electric light pencils which is described in the original Gauduin patent is different from that which is given in the first certificate of addition thereto. 546

The former consists in producing a very pure coke by decomposing carbonaceous materials in close vessels and in mixing this coke after pulverization with tar, pitch or similar material to a plastic mass and subsequently carbonizing it.

The second method consists in shaping the pencils out of dry and properly selected wood and converting them into a hard and compact carbon by impregnating it with tar, bitumen, sugar, caramel, etc., and heating it to a high temperature in a reducing atmosphere. 547

Inasmuch as the object, as I suppose, was to produce carbon pencils which should be as good conductors as practicable, I think both of the methods above mentioned would be worked to secure this end. Indeed, with regard to the second method the quotation distinctly states that the object is converted by it into a "hard and compact carbon."

It appears to me, therefore, that the specific resistance of the Gauduin carbons made by either of the methods described in the Gauduin patent might very 548
readily be materially different from that of the carbon filaments made from tar and lamp black with the object in view which the patent in suit seeks to attain.

126 x-Q. Assuming, if you please, that Edison intended to produce by the carbonization of his compound of tar and lamp black, a carbon of higher specific resistance than Gauduin intended to produce by the process set forth in his original patent, in what way would a person skilled in the art as it existed at the date of the Edison patent (and without knowledge and skill

549 since acquired) have proceeded to produce these different results, if he had been called upon to make carbons under the Gauduin and the Edison patents respectively ?

A. It seems to me that such a person might increase the porosity of the carbon by suitably selecting the materials and suitably varying the proportions in which they are mixed.

127 x-Q. What choice of materials, in your opinion, would a person have made for the two carbons under
550 the hypothesis of the last question and in what proportions would he have mixed them ?

A. That would depend, I think, upon the result which he wished to obtain. If he wished a carbon of the maximum porosity he might use the materials which give a highly porous mass on carbonization and mix these with materials suitable for the purpose which were lighter and not denser in mass ; and this in such proportions as to increase in general the amount of volatilizable material.

551 128 x-Q. Suppose, for instance, when working under the Gauduin patent he had used the "pure coke" made as described by Gauduin and pulverized and mixed with tar and then shaped the plastic mass into form and carbonized it, how would the resulting carbon have compared in specific resistance with a carbon made by mixing lampblack and tar and then shaping and carbonizing as set forth in the Edison patent, and if you think the former would have had a lower specific resistance than the latter, please state why ?

552 A. It is difficult to give a definite answer to so general a question. Supposing the coke in the former case to be denser than the lampblack in the latter, and supposing the tar to be used in larger proportion in the second case, and supposing the material to be rolled out in the second case with only a slight pressure while the material in the Gauduin process is forced through a die, then it seems to me reasonable to suppose that the carbon made by the Gauduin process might be denser and so of lower specific resistance.

129 x-Q. To what would this assumed difference of 553
specific resistance in the two carbons be due ?

A. More or less entirely, I suppose, to a difference in the state of aggregation, other things being equal.

130 x-Q. To what would that difference in aggregation be due ?

A. Other things being equal, to the closeness or remoteness of the particles, of course. This arises from the fact, I suppose, that a denser carbon was used in one case or the other ; that less tar was used and that
the mass was consolidated by pressure. 554

131 x-Q. In answer to cross-question 128, you say that you deem it "reasonable to suppose that the car- "bon made by the Gauduin process might be denser "and so of lower specific resistance" than the carbon made under the Edison patent by the use of tar and lampblack. Might it not also be that a Gauduin carbon might have a higher specific resistance than one of these Edison carbons ?

A. Of course, as a question of fact, I cannot say in
the absence of any data on the subject that a carbon 555
made by the Gauduin process might have higher specific resistance than that obtained by carbonizing a lampblack and tar filament at a high heat in a closed chamber. But my judgment is that such would not be the case since I find that Fontaine, in speaking of Gauduin's process, says :

> "The objects made in agglomerated carbon are for one variety of carbon as much more combus-
> tible as they are porous, and as much more porous 556
> as they are molded with less pressure. The inventor himself uses for his manufacture steel molds capable of resisting the highest pressure of a strong hydraulic press."

132 x-Q. Evidently in the last answer you have been comparing with the Edison carbons the Gauduin carbons as actually made by the tools and process which a man by the name of Fontaine says that Gauduin at one time used—the apparatus thus employed by Gauduin being evidently different from the "die"

557 which the original Gauduin patent speaks of as the thing to be used in shaping the carbons. I now ask you whether it is your opinion that a carbon made by the use of pure coke and tar in the manner described in Gauduin's original patent might not have as high a specific resistance as a carbon made of lamp black and tar under the Edison patent in suit?

A. The assumption of the question seems to me an entirely incorrect and inaccurate one. It is true that the quotation in my last answer is taken from Fon-
558 taine's book; but it is there given as part of a resume of the Gauduin patent itself. If, however, M. Fontaine's statement is not sufficient I will make the quotation directly from the Gauduin patent itself as follows:

> "The articles made of agglomerated carbon are, taking the same kind of carbon, more combustible as they are more porous and more porous as they have been molded at less pressure. I use molds of bronze, cast iron or steel capable of resisting the
> 559 greatest pressure of a strong hydraulic press."

I have nothing to add, therefore, to my last answer.

133 x-Q. Does not the Gauduin patent also provide for shaping his carbons by forcing the plastic mass of tar and pulverized coke through a die?

A. The Gauduin patent says in the next paragraph following the one just quoted:

> "Although the draw-plate (filière) or moulding apparatus long used in the manufacture of the pen-
> 560 cils of carbon soot, plumbago (graphite), etc., intended for writing or drawing might serve without any modification for the manufacture of pencils for electric lighting; I have made certain improvements in this apparatus the exclusive use of which I desire to reserve. Instead of causing the pencils to go out from top to bottom going vertically I place the (here is an omission) or the orifices of the mold on the side, and in such a manner that the pencils pass out forming with the horizon a descending angle from 20 to 70 degrees. They are guided along their whole length by tubes or by

> channels (grooves). This arrangement enables me 561
> to empty out all of the material contained in the mold without interrupting the work, and as the pencils are constantly supported they no longer break under their own weight, which often happens when they pass downwards. It is above all useful in the manufacture of thick and long pencils intended to be used as positives, in electro-chemical decompositions, these carbon positives replacing advantageously the platinum. Figure 3 represents
> a pencil-mold with outlet pipe on the side." 562

The expression "forced through a die" seems to have been taken from my answer in the McKeesport case quoted in cross-question 125. It is my paraphrase of the quotation just given from the Gauduin patent, the word "die" being used as the equivalent of the term "draw plate" or "filière." The mold mentioned in the above quotation, and which is shown in figure 3, I suppose to be one of the molds referred to in the quotation given in my last answer.

134 x-Q. Was not carbon having a specific resistance 563
substantially the same as that of the carbon composing the filament of Claim 1 of the patent in suit old in the art of electric lighting—both for arc lighting and as the burner of incandescent lamps—prior to the date at which Mr. Edison filed his application for the said patent?

A. The use of pencils of charcoal had been proposed, I believe, for both incandescent and arc lighting before the date of the patent in suit. And this charcoal may
very probably have had substantially the same specific 564
resistance as that of the carbon filaments of the first claim produced by carbonization.

135 x-Q. Were those carbons included among those which are referred to in the Edison patent in suit as used in the prior incandescent lamps?

A. That I do not know, as the patent itself does not furnish data upon this point so far as I understand it; and I have no knowledge of my own upon the matter.

136 x-Q. Then, so far as you know, those carbons

565 may have been included in the reference which the patent makes to the prior state of the art?

A. I cannot say whether or not it is the intention of the patent to include them.

Answer objected to as not responsive.

137 x-Q. (Question repeated.)

A. I can give no better answer than the last.

138 x-Q. What do you mean by the term "specific
566 resistance" as applied to the carbons used in electric lighting?

A. I mean the resistance of the carbon itself as a substance independent of the dimensions which it may have.

139 x-Q. How would you state the specific resistance of any particular carbon or other substance?

A. The absolute specific resistance of a substance is the resistance of a cubic centimetre of that substance, expressed in ohms.

567 140 x-Q. Now, can you state in ohms the specific resistance of any of the different kinds of carbon which were used in electric lighting, either arc or incandescent, prior to the date of Edison's application for the patent in suit.

A. I cannot. I know of no reliable data which would enable me to give the specific resistance called for.

141 x-Q. I conclude, therefore, that you have not personally tested the specific resistance of any of the old carbons referred to?

568 A. I do not remember that I have personally measured the resistance of any of the carbons in use prior to the date of the patent in suit for arc lighting.

142 x-Q. Do you know of any method by which it would be possible now to ascertain what in fact was the specific resistance of the old carbons that were actually used prior to the invention covered by the patent in suit?

A. I should think that the easiest way, if practicable, would be to collect some of the carbons made for use

in electric lighting before the date of the patent in suit 569
and to measure them.

143 x-Q. What do you understand the patent means by the statement made with reference to the prior state of the art, that,

> "the attempts of previous persons have been to
> "reduce the resistance of the carbon rod?"

A. I understand the patentee here to express his opinion that, speaking generally, the tendency of pre-
vious experimenters had been rather to diminish the 570
resistance of the carbon rod serving as the burner of the lamp than to increase it, the direction in which he himself proposed to vary it.

Adjourned till Saturday, the 16th inst., at 10½ A. M.

SATURDAY, Nov. 16, 1889. 571

Met pursuant to adjournment.

Present—Counsel as before, and the cross-examination of PROF. BARKER by GEN'L DUNCAN continued as follows:

144 x-Q. "Diminish" it from what as a standard?

A. I do not know that there was any generally accepted standard of resistance for the carbon rods which had been used in obtaining light by incandescence.
The patent itself speaks of these rods thus used as 572
having had in some cases from one to four ohms resistance, and I understand the patentee to express the opinion that the tendency of previous persons in general had been in the direction of attempts to reduce the resistance of the carbon rods below this value rather than to increase the resistance of the carbon rods above it.

145 x-Q. Do you understand that the term "resistance" in this connection refers to the *specific* resistance

573 of the carbon or to the *total* resistance of the burner made from the carbon?

A. The patent itself says,

> "that a lamp having but one to four ohms resist-
> " ance cannot be worked in great numbers in mul-
> " tiple arc without the employment of main con-
> " ductors of enormous dimensions,"

referring, as I suppose, to lamps whose burners were the rods of carbon of one to four ohms resistance, men-
574 tioned just above. This leads me to believe that the resistance here spoken of is intended to be total resistance.

146 x-Q. Then, as I understand from your last two answers, the statement of the patent that "the at-" tempts of previous persons have been to reduce the " resistance of the carbon rods" means that they had, prior to the date of the patent in suit, attempted to reduce the total resistance of the carbon burners of incandescent lamps to a point below "one to four
575 ohms;" does this correctly state your view?

A. In the quotation given in the question, I understand the patentee to express the opinion that the tendency of previous persons in general had been in the direction of attempts to reduce the total resistance of the carbon rods rather than to increase it. And since in some cases, these rods of carbon, as the patent states, had from one to four ohms resistance, I think the inference a fair one that in the opinion of the inventor, the tendency of previous persons above re-
576 ferred to had been to reduce the total resistance of the carbon rods below this value rather than to increase it above it.

144*a* x-Q. What, generally stated, were the methods by which these "previous persons" sought to reduce the resistance of carbons used in incandescent lighting?

A. I do not know, of course, what specific instances of the tendency of previous persons to reduce the resistance of the carbon rods used in the old lamps, the patentee himself may have had in mind; if indeed, he

had any particular instance under consideration. 577
Generally stated, however, I suppose that a person seeking to reduce the resistance of a carbon rod would diminish its length or increase its section or make it of that variety of carbon available to him which had the lowest specific resistance. Since these methods of varying the resistance of a carbon rod, so far as I know, are all the methods of accomplishing this result, it is evident that previous experimenters must have used one or the other of these methods or some combination of them. 578

145*a* x-Q. And if they had sought to make use of a carbon having the lowest specific resistance, how, if you know, would such carbon have been prepared?

A. I do not know, of course, what the minimum specific resistance is which it is theoretically possible to obtain in the case of carbon. But I should suppose that a carbon would have a lower specific resistance, other things being equal, in proportion as it is denser, and therefore, that the methods employed to obtain a carbon of high specific conductivity would be methods 579
calculated to increase its density.

146*a* x-Q. What special method, if any, have you in mind as belonging to the prior state of the art and which you think would likely have been applied under the circumstances named in the last question?

A. I do not remember to have had in mind any specific method of preparing carbons having a low specific resistance. The great importance in arc lighting of having the carbon pencils used for the purpose, of as high conductivity as possible, was generally 580
recognized at the date referred to. And my recollection is that manufacturers of these carbon rods and pencils in general addressed themselves to the obtaining of the carbon itself in the densest attainable form. Thus, for example, the French patent to Gauduin, in 1876, as already pointed out in my 125th cross-answer, *et seq.*, gives two processes for making these pencils, both of which would result in the production of a hard, dense and compact carbon. Moreover, the process of Carré, already alluded to in my 105th and 110th cross-

581 answers, would also result in the production of a dense and compact carbon.

147 x-Q. Do you think that the simple direction of the patent in suit to "carbonize" a cotton thread, without an explanation of the process covered by the term "carbonize," would have been sufficient to enable a person skilled in the art of electric lighting as it existed on the day when Edison filed his application, without experiment, to make a practically serviceable carbon for an incandescent lamp?

582

Objected to as new matter, and as to which the defendant makes the witness its own.

A. I do.

148 x-Q. Upon what facts do you base this opinion?

Same objection.

A. On the facts which characterized the state of the
583 art with regard to the carbonizing process, so far as I have been able to ascertain them at the date when the application for the patent in suit was filed. In my 103d cross-answer, I said, "I do not understand that "the process spoken of in the patent in suit as carbon- "ization is materially different from processes which "were known and practiced prior to the date of the "patent." The process of carbonization is generally held to consist in the production of carbon from materials containing it by driving off by heat the volatile
584 portions of these materials. Clearly, since all substances containing carbon do not leave a carbon residue when thus heated to a high temperature, some of these substances cannot be used for the purpose. Moreover, since carbon is combustible at a high temperature, it is obvious and has long been known that to obtain the maximum yield of carbon by the process of carbonization, it is necessary to exclude the air during the operation. The process of charcoal-burning, which is a very old and familiar one, is an illustration of this fact; the pile of wood being covered with clods of earth in the

older methods, or heated in closed iron cylinders in the 585
newer methods, for the purpose of preventing the access of the oxygen of the air.

In case it is desirable to preserve the carbon without loss it has long been the custom not only to place the substance to be carbonized in a closed chamber, but also to fill this chamber or vessel with a substance like sand to replace the air of the vessel. The earliest carbon pencils, I think, which were used in arc-lighting were made by carbonizing pieces of wood in crucibles
filled with sand. Since the interstices among the par- 586
ticles of the sand contain oxygen and since there may possibly be some leak of air into the vessel during the carbonizing process, it became the custom to replace the quartz sand by carbon sand, dust or powder which not only accomplished the same result, but also itself absorbed the oxygen contained in the vessel. This latter process of carbonization I understand is the one which was employed by Carré in the preparation of his carbon pencils for electric lighting.

587

Adjourned for lunch.

Resumed after lunch.

149 x-Q. Do you mean to intimate by your last answer that at the date of Mr. Edison's application for the patent in suit, it was known by persons skilled in the art of electric lighting that the process of carbon-
ization described by you was applicable to cotton 588
thread?

Same objection.

A. The patent in suit speaks of "a cotton thread "properly carbonized" as possessing important advantages as a burner of the new lamp proposed by Mr. Edison. Inasmuch as the specification speaks of "cot- "ton and linen thread, wood splints, paper coiled in "various ways," as having been carbonized for the

589 same purpose; and inasmuch as the process of carbonization may be quite the same as applied to all these materials and may be substantially the same as processes of carbonization used in the case of other forms of woody fibre before the date of the patent, I am led to the conclusion that a person skilled in the art of carbonization as it was known at that time would have had no difficulty in so applying the process to the carbonization of a cotton thread as to produce a practically serviceable carbon burner for an incandescent lamp.

590 150 x-Q. Is this conclusion one drawn simply from the statements of the patent, or is it based upon some knowledge by you that thread had actually been carbonized by well-known processes before the date of the application for the patent?

Same objection.

A. The patent itself speaks of "a cotton thread "properly carbonized." It also says that the tar-putty
591 filament is to be "carbonized in a closed chamber by "subjecting it to high heat." These directions of the patent seem to me, in view of the state of the art at the time, quite sufficient to enable a person skilled in the art to perform the operation successfully and to produce a practical carbon burner; since the process as applied to the cotton thread and the tar-putty filament need differ in no essential particular from the process as applied to the carbonization of wood.

In Gauduin's patent of 1876, he says in one of the
592 certificates of addition thereto,

"I also manufacture articles of carbon from cotton, "hemp, flax, cellulose, in any state, kneaded and impregnated with pitch, tar, etc., and formed so as to "give it the desired shape."

151 x-Q. You understand, do you not, that it was old in the art at the date of the application for the patent in suit, to give to the crude material the desired shape of the carbons to be used in electric lamps and then to carbonize it after it had assumed that shape?

Same objection.

A. I do not quite understand the sense in which the 593
word "shape" is used in the question. This word is not used, I believe, in the patent in suit and I do not understand that any particular shape of the burner is therein claimed, provided that the said burner be of carbon, and be in a filamentary form.

I understand that it was old at the date of the patent to give to the materials to be carbonized for arc lighting purposes the form of pencils before carbonization.

152 x-Q. Was it not old prior to the date named,
both for arc lighting and for incandescent lighting, to re- 594
duce the crude material before carbonization to the form or shape in which it was finally to be used in the lamp and to carbonize it afterward?

Same objection.

A. It was, in the sense in which the Gauduin's carbons, for example, were so used. In this case the same plastic mass was forced through the draw plate and
gave pencils or rods of various sizes according to the
size of the opening in the draw plate. These pencils 595
were then baked. The larger sizes were used in arc lighting, and the smaller in some of the old incandescent lamps which had straight burners.

153 x-Q. Does the expression "made as described" of the first claim of the patent in suit mean anything more than that the material operated upon is to be shaped first and then carbonized?

A. I understand that the expression "made as described" refers to the making of the burner by first 596
giving the material before carbonization and when it can be easily manipulated, the filamentary form, and then subjecting it to carbonization.

154 x-Q. What does the adverbial expression "as set forth" of claim 1 of the patent modify?

Objected to as usurping the functions of the Court.

A. The question seems to me to call for a legal opinion on the construction of the language of the claim

597 and not for a scientific opinion of fact, and hence I do not feel competent to answer it. As I understand the practice, the expression is the substantial equivalent of the words "for the purposes set forth," which terminate the second claim.

It is stipulated that the complainant's time to take its *prima facie* evidence be extended to include Wednesday, November 20th next.

598 Adjourned to meet at the Hotel Stratford, Philadelphia, on Monday, the 18th inst., at 2 o'clock P. M.

HOTEL STRATFORD,
PHILADELPHIA, Nov. 18, 1889.

Met pursuant to adjournment.

Present—Counsel as before, and the cross-examination of PROFESSOR BARKER was continued as follows:

599

155 x-Q. In what sense did you understand these words "as set forth" to be used in claim one when you gave your direct testimony?

Objected to as immaterial.

A. I do not remember to have specially referred to the words "as set forth" in my direct testimony. If I am entitled to express an opinion they seem to me to be the equivalent of the words "for the purposes set
600 forth," which end the second claim.

156 x-Q. Did you not in your own mind put a construction upon these words of the first claim when you gave your direct testimony?

Same objection.

A. I do not remember to have done so, except in the very general way in which that and other similar expressions which ordinarily terminate the claims of patents are considered.

157 x-Q. Did you in this general way put a construc- 601
tion upon those words of the first claim when giving your direct testimony?

Same objection.

A. I have always had the impression that the words "as set forth" were intended to apply to the entire claim, although I do not know that I am qualified to express an opinion upon this subject, which appears to me a matter to be determined by the Court. 602

158 x-Q. My question is this: Whether you did or did not, in your own mind at least, put a construction on these words, "as set forth," in the first claim when you gave your direct testimony?

Same objection.

A. I do not understand the purely technical and legal sense in which the words "put a construction" seem to me to be used in the question. So far as I do
understand it, I do not think that I can answer the 603
question better than by saying that I suppose now and did suppose at the time of my giving my direct testimony, that the words "as set forth" at the end of the first claim are intended to apply to the entire claim. If this be what is meant by "putting a construction" on these words, then as I understand it, it seems to me that I may say that I did in my own mind put a construction upon these words at the time of giving my direct testimony. 604

159 x-Q. I will try to make my meaning clear. When you gave your direct testimony did you suppose that the concluding words of claim 1, "as set forth" were without meaning?

Same objection.

A. I do not remember to have done so.

160 x-Q. Do you remember whether you then supposed that they had some meaning?

Same objection.

605 A. My impression was then and is now that as applied to the entire claim they were intended to have some meaning.

161 x-Q. What meaning did you then suppose those words had?

Same objection.

A. These words seem to me simply to indicate that the electric lamp should consist, substantially as set forth
606 in the specification and for the purposes there set forth, of a filament of carbon of high resistance made as described and secured to metallic wires.

162 x-Q. Is it your opinion, then, that the words in question add anything to the meaning of the claim as it would necessarily be construed if those words were not there?

Same objection.

607 A. I understand that the words, "as set forth," "substantially as set forth," "for the purposes set forth," etc., are employed for the purpose of connecting the very tersely expressed claims of a patent with the more amplified specification. It does not seem to me that the words in question necessarily add anything to the meaning of the claim, provided that this meaning be understood in the light of the specification.

163 x-Q. I do not ask you whether generally these words "necessarily" add anything to the meaning of a
608 claim to which they are appended; what I ask is, whether, in your opinion, in the particular case in question—to wit, claim 1 of the patent in suit—these words in any respect modify or change the meaning of the claim from the meaning which it would bear if these words were omitted?

Same objection, and as calling for a judicial construction as to whether the words quoted legally refer to the claim alone or to the specification alone or to both or to neither, and as to

which the opinion of the witness is useless, and, 609
therefore, impertinent and irrelevant.

A. Not necessarily; by which I mean that this seems to me only a special case under the general rule stated in my last answer. That is to say, that provided the meaning of the claim be understood in the light of the specification, the words, "as set forth," may not add anything to the meaning of the claim; while if the meaning of the claim be not so understood, these words would be significant and would call attention to the 610
importance of construing it in the light of the specification.

164 x-Q. You still fail to answer my question. I do not care for your speculations as to what under certain circumstances may or may not be the value of the words in question in claim 1 of the patent, but I *do* desire to know whether, in *your* opinion, at the time when you gave your direct testimony, these words conferred upon the claim any modification of the meaning which the claim would have had without them. I also 611
desire to know whether your opinion upon this point has undergone any change since your direct testimony; and if so, what?

Same objection, and as being already answered, and also as the expensive pursuit for a layman's opinion upon what is really a judicial question.

A. I have no knowledge on the subject other than 612
that which I derive by deduction from general principles. Whether in this specific case the words "as set forth" would or would not add anything to the meaning of the claim would depend, as it seems to me, upon what that meaning is understood to be. Hence my last answer.

I cannot, therefore, better answer the question as an expert (in so far as an expert is competent to express an opinion upon what seems to me a legal question) than by saying that, in my opinion, "in the particular

613 case in question, to wit, claim 1 of the patent in suit, these words "do not in any respect necessarily modify or change the meaning of the claim from the meaning which it would bear if these words were omitted;" to use the words of the 163d cross-question.

If, however, the question is intended to be a personal one; that is to say, if it is important to this case to know whether, as a matter of fact, the words "as set forth" at the end of claim 1 did confer any additional meaning upon the claim itself at the time of giving my
614 direct testimony, so far as I personally am concerned, then I think I should say that they did not; since I had already read the specification many times carefully and therefore readily interpreted the claim in the light of the specification.

165 x-Q. From this I understand that when you gave your direct testimony, the words "as set forth" of the first claim were not regarded by you as in any way modifying the meaning of the claim? Was this
615 your view of those words at that time?

Same objections.

A. I can only say that, so far as I now recollect, the words "as set forth" which terminate the first claim, did not, as a matter of fact, communicate to me any additional meaning which I had not already detected in the claim itself as a consequence of my study of the specification.

166 x-Q. Then you did not regard them as modify-
616 ing the claim in any respect, did you?

Same objections.

A. I should hardly like to say that, so far as the interpretation of the claim by others is concerned. As for myself, I am not conscious that these words affected my interpretation of the claim.

167 x-Q. You have assumed that the first claim includes by necessary implication a glass globe. Please state whether it is also necessary to the invention covered by the first claim that such globe be exhausted?

A. I think that it is, since the specification says: 617

"The invention further consists in placing such burner of great resistance in a nearly perfect vacuum to prevent oxidation and injury to the conductor by the atmosphere. The current is conducted into the vacuum bulb through platina wires sealed into glass."

168 x-Q. Do you also hold that the glass globe which you say is a necessary element of Claim 1 is the same thing as the "receiver made entirely of glass," 618
which forms an element of the *second* claim?

A. Substantially; yes.

"The particular lamp chamber or globe described in the patent is an exhausted chamber of an entire piece of glass hermetically sealed by the fusion of the glass, and is the only one I know of which is practically useful."

169 x-Q. Of course you consider that the metallic wires spoken of in the first claim must "pass through the glass" composing the globe which you say is an 619
element of the first claim?

A. I do; since the specification states, "the current is conducted into the vacuum bulb through platina wires sealed into the glass."

170 x-Q. Do you consider that the "conductors" spoken of in the second claim must be "metallic wires?"

A. I think so, since I know of no conductors other than metals which would be practicable for the purpose. 620
I suppose, however, metallic strips might serve the same purpose as wires.

171 x-Q. Do you mean by your last answer to intimate that if one were to use metallic "strips" to carry the current into an incandescent lamp he would not use the invention of the first claim?

A. I do not, since the term "wires" seems to be used broadly in electric science, and is not limited to a circular cross-section.

172 x-Q. In view of your last few answers, is there,

621 in your opinion, any other difference between the first and second claims of the patent in suit than the possible difference in the specific resistance of the carbon filaments to which you have heretofore referred, and the further difference that the filament of the first claim is to be made by first giving the crude material a filamentary form and then carbonizing it, while the second claim is not limited to this order of events in making the filament?

A. The substantial difference between the first and
622 second claims, as claims, seems to me to lie in the fact that while the filament of the first claim is to be a filament of carbon of high resistance, *i. e.*, is to be composed of a particular kind of carbon, and is to be "made as described," *i. e.*, by giving the material the filamentary form before carbonization, the carbon filament of the second claim is not so limited.

If there are any other differences they seem to me such only as are necessarily involved in the idea of the electric lamp structure of the patent and which are
623 necessary to render it operative. These other differences, however, between the claims seem to me to be differences of language rather than of substance.

173 x-Q. Do you recognize any relation as existing between the mode of making the carbon filaments spoken of in the first claim and the specific resistance of the burner produced by such mode of manufacture; in other words, do you consider that the mode of manufacture referred to in the words "made as de-
624 scribed," is essential to the production of a filament having the resistance spoken of in the claim as "high resistance?"

A. The first claim requires two things, as I understand it; first, that the burner shall be "a filament of carbon of high resistance"; and second, that this burner shall be "made as described." As a matter of fact, I believe the materials spoken of in the patent as subjected to carbonization to form the filament of carbon of high resistance, are materials easily worked into the filamentary form before carbonization. So that under

these circumstances the production of the filamentary 625
burner from these materials by carbonization would result necessarily in the production of a carbon of high specific resistance. It seems to me, therefore, that there is a relation existing between the mode of making the carbon filament and the specific resistance of the carbon produced by it.

174 x-Q. Do you then consider that it is necessary, in order to produce the "carbon of high resistance" spoken of in claim 1, that it shall be produced by first reducing the crude material to the desired form for use 626
and then carbonizing it?

A. It seems to me that the first claim requires that the filament of carbon of high resistance should be made as described, that is, by reducing the material employed for the purpose to the filamentary form and then carbonizing it; or, in other words, that the expression "made as described," refers to the expression "filament of carbon of high resistance" taken as a whole.

175 x-Q. What I wish to know is this: Whether, as 627
you understand the matter, the "high resistance" spoken of in the first claim (by which I understand you to mean high specific resistance) can be conferred upon carbon otherwise than by first reducing the crude material to the desired form and then carbonizing it?

A. I do not know that I quite understand the question. The carbon of high specific resistance of the first claim has nothing peculiar about it, as I view the matter, other than its porosity. I do not under-
stand that Mr. Edison devised any new variety of 628
carbon. He simply selected that variety of carbon already in existence which, because of its porosity, had a high specific resistance, and thus made his filamentary carbon burner electrically of still smaller cross-section. Such carbon possessing this porosity and high specific resistance is the variety of carbon produced by subjecting certain materials to a high temperature, whereby the volatile portions pass off leaving the carbon in the porous condition. Charcoal, as I understand it, is an example of

629 carbon of greater or less porosity and therefore of greater or less specific resistance. Carbonization is obviously the readiest method of obtaining this variety of carbon; but I should not like to say that other and more complicated chemical processes might not result in the production of carbon as porous and of as high specific resistance.

176 x-Q. Let me put my question in this way: Is the assumed high porosity and consequent high specific resistance of the carbon composing the filament of the
630 first claim due to the fact that the crude material out of which it is made is reduced to the desired form for use before it is carbonized?

A. I think that I should answer both yes and no to this question. It is quite obvious, as it appears to me, that a substance cannot be carbonized unless it has some form previously, and therefore it could not have the porosity and specific resistance of the resulting carbon without having been put into some form or other intentionally or accidentally before carbonization. I
631 do not know, for example, how a piece of ordinary charcoal could be produced except from a previously existing piece of wood; this, of course, having a definite form. In this sense the crude material out of which the porous carbon is made must be reduced to some form or other before it is carbonized.

On the other hand it seems to me that the porosity and consequent specific resistance of carbon produced by carbonization is quite independent of the particular form given to the material to be carbonized before sub-
632 jecting it to heat. I do not see, for example, that the porosity and specific resistance of boxwood charcoal would necessarily be materially different if the piece of boxwood carbonized were in the form of a sphere in one case and of a cube in another. So that in this sense I should say that the porosity and specific resistance are independent of the form into which the material is put before carbonization.

It seems to me to follow, therefore, that the porosity and consequent high specific resistance of the carbon composing the filament of the first claim is independent

of the form into which the material is put before car- 633
bonization.

177 x-Q. It follows, then, does it not, that the reducing of the crude material to the filamentary form before carbonization (which, as I understand you, is what is implied by the words "made as described" of the first claim), has no other object than the securing of a small cross-section to the burner?

A. That is as I understand it.

Adjourned to Wednesday, the 20th inst., at 11:30 634
A. M.

WEDNESDAY, November 20th, 1889.

Adjourned to 22d inst., at 10 A. M.

NEW YORK, Friday, Nov. 22, 1889. 635

Met pursuant to adjournment at Mr. Seward's office.

Present—Counsel as before, and the cross-examination of DR. BARKER by GEN'L DUNCAN continued as follows:

178 x-Q. And that means, I presume, that the object in first reducing the crude material to the filamentary form, and then carbonizing it is to secure a high total resistance?

A. Not necessarily, I think, since the total resistance 636
of the burner is a function of the length, as well as the area of the cross-section, and the specific resistance of the material. The object of selecting carbonizable material seems to me to be two fold. In the first place, such materials are readily worked to the size required (or in some cases may be selected of suitable size), and hence it is an easy matter to put them into the filamentary form, and to secure uniformity in their section throughout their length. In the second place such material gives on carbonization a carbon of high specific

637 resistance, and therefore still further reduces the size of the filament. Moreover, carbonization of such material after reduction to the filamentary form secures greater uniformity of carbonization, as it seems to me, throughout its length. I think, therefore, that these are the objects aimed at in first reducing the crude material to the filamentary form and then carbonizing it.

179 x-Q. Do you mean by your last answer to be understood as saying, among other things, that one of the
638 objects in first reducing the material to the filamentary form before carbonization is to secure a high specific resistance in the carbonized product?

A. I do not, since I think that the same material carbonized in the same way might yield a carbon of the same specific resistance whatever the special form into which the material is put before carbonization.

180 x-Q. Returning now to the meaning of the word "filament." Does this term as used in the second claim of the patent in suit, indicate anything more to
639 your mind than that the burner is to be of such dimensions that it will have a sufficient resistance to enable it to be used practically in multiple-arc?

A. In my direct examination, I said:

> "the word 'filament' means primarily a thread-
> "like body; and I understand the term 'carbon
> "filament' to involve a carbon conductor of a
> "small or thead-like cross-section. * * * These
> "considerations lead to the conclusion that the
> 640 "filament of carbon of the first claim" (and therefore the carbon filament of the second claim, which I understand to be synonymous with it), "is a carbon "conductor of any length and of a cross-
> "section sufficiently small to produce the impor-
> "tant results which have been referred to."

Inasmuch as it is the high total resistance of a lamp which enables it to be used on a multiple-arc circuit, and since this high total resistance is a function of the length of the filament, I am led to the conclusion that the term "carbon filament" of the second claim indi-

cates rather the small cross-section of the filament upon 641
which the lamp itself depends, than the length of the filament, upon which the practical use of the lamp on a multiple-arc circuit is based.

181 x-Q. I conclude, then, that you would hold the second claim to include series lamps as well as multiple arc lamps?

A. I understand the second claim to cover the combination of a carbon filament as a burner with a peculiar receiving chamber and with platinum conductors sealed into the glass, the said receiver being exhausted. 642
Provided, therefore, a given lamp embodied the combination of the second claim, it seems to me that it would not be material, the conditions being suitable, whether it was used in series with other lamps or in multiple arc with them.

182 x-Q. Would it be material whether it was made with a burner of comparatively low total resistance, so as to be specially adapted for series work, or of comparatively high total resistance so as to be specially adapted for multiple arc work? 643

A. It does not seem to me that it would. In my 71st cross-answer I said:

> "The term 'filament' seems to me to involve
> "the idea of small cross-section, and not the idea
> "either of length or of resistance."

Provided, therefore, that the carbon burner of the lamp be in the filamentary form and be inclosed in an exhausted receiver made entirely of glass, having conductors passing through the glass, etc., as stated in 644
the second claim, I think that the total resistance of the lamp produced by varying the length of the filament may be varied indefinitely to suit the circuit on which it is to be used, without departing from the invention therein set forth and claimed.

183 x-Q. Do you also regard the *first* claim of the patent as broad enough to include both series lamps and multiple arc lamps?

A. I suppose the distinction referred to in the question between "series lamps" and "multiple arc lamps," to

645 be founded only on the fact that one has a higher total
resistance than the other. In my 57th cross-answer
I pointed out the fact that if the conditions of the two
circuits are suitable, the same lamp may be used
either in series with other similar lamps or in parallel
with them; *i. e.*, in multiple arc with them. Since,
therefore, the same lamp may be used on a series cir-
cuit or a multiple arc circuit, and since the lamp may
be such a lamp as is made under the first claim
of the patent in suit, its burner being in the fila-
646 mentary form and made of carbon of high resistance,
as described, it seems to me that it is not material
whether the lamp made under the first claim be used
in series with the other lamps or in multiple arc with
them.

184 x-Q. Do you know what is the specific resist-
ance of the carbons used in defendant's lamps?

A. I do not.

185 x-Q. Might not the specific resistance of the de-
fendant's carbons be computed from the facts contained
647 in the stipulation heretofore made respecting them?

A. The specific resistance of a carbon can, of course,
be computed if the total resistance of the carbon be
given, as well as its length, its breadth and its thick-
ness. Understanding the data given in the stipulation
to refer to the carbon itself, it seems to me that the
specific resistance of these carbons might be calculated
from these data.

186 x-Q. Do you know what particular lamps are re-
ferred to in the patent in suit as belonging to the prior
648 state of the art?

A. I do not know what particular lamps, if any, the
patentee had in mind when he applied for the patent
in suit and which he refers to in the specification.

187 x-Q. Then of course, you do not know by what
particular process the carbons of those lamps were
made?

A. I do not.

188 x-Q. Then how are you justified in saying (as I
understand you have said in cross-answer 99) that "the
" carbon of the burners of the old lamps," referred to

in the patent, was "made by a process calculated to 649
" consolidate it and make it dense and compact"?

A. It seems to me that my own knowledge of the
state of the art justifies the opinion which is quoted in
the question. In my 101st cross-answer I said:

> " On the other hand the patent speaks of rods of
> " carbon 'of one to four ohms resistance,' as the
> " form which was given to the burners of the old
> " lamps. Since I know that at least in some of the
> " old lamps answering to the description of them
> " which is given in the patent, 'the rods of carbon' 650
> " were made by a process calculated to consolidate
> " the carbon and to make it dense and compact, I
> " expressed the opinion that the carbon constitu-
> " ting the burners of the old lamps was, in general,
> " denser and of a lower specific resistance than the
> " carbon of the patent in suit, produced by the
> " carbonization there described."

189 x-Q. In one or two places in your testimony you
appear to have assumed that the burner of the patent 651
in suit is characterized by a high degree of elasticity
and flexibility. Do you find any statement in the patent
that a high degree of elasticity and flexibility is a
characteristic of the carbon or burner described in the
patent?

Objected to as it is not necessary for a patentee
to state in his specification all the benefits which
result from his invention.

652

A. I do not find that the patent itself specifically
states that the carbon filament is elastic and flexible.
But I know, as a matter of fact, that a carbon filament
made by the process of the patent, does possess the
property of elasticity and flexibility in a high degree;
and hence I thought myself authorized to enumerate
elasticity and flexibility among the advantages charac-
teristic of the filamentary form of the burner, in virtue
of which it can be attached to terminals rigidly fixed in
position and this without endangering the integrity of
the filament from shock or expansion.

653 190 x-Q. To what in the "process of the patent" do you refer, when you say that "a carbon filament made "by the process of the patent does possess the prop- "erty of elasticity and flexibility in a high degree"?

A. The advantages of elasticity and flexibility in a carbon filament, arise in my judgment, both from the filamentary form of the burner and from the material composing it. That part of the process of manufacture which puts the material into the filamentary form and then reduces it to carbon would therefore seem to be
654 that, in the process of the patent, which confers upon the burner the property of elasticity and flexibility.

191 x-Q. How far does this high degree of elasticity and flexibility depend upon the *length* of the filament?

A. I should think the flexibility might increase with the length of the filament, but I do not think that the elasticity need be materially altered.

192 x-Q. Does the elasticity bear any relation to the density or specific resistance and, if so, what?

A. I do not know that there is any necessary re-
655 lation between the density of a carbon and its elasticity.

193 x-Q. As a rule, does not the elasticity of a substance increase with its density, and is carbon an exception to this rule?

A. It is obviously not true that the elasticity of *different* substances increases with the density; since, for example, aluminum, one of the lightest of metals, is very much more elastic than lead, which is one of the heaviest. Hence it is evident that elasticity and den-
656 sity do not necessarily increase and decrease together. The atmosphere about us is less dense at a high temperature than at a low one; but its elasticity may remain the same. I do not recall any specific instance where the increase in the density of a body increases its elasticity in the same ratio, showing that the one is dependant on the other.

194 x-Q. To be more precise, would not a given mass of carbon be more elastic according as it is made more dense?

A. I do not see why it should be so necessarily. It

seems to me that the elasticity of a given mass of box- 657
wood charcoal, for example, might be actually diminished by strongly compressing it by hydraulic pressure.

195 x-Q. The patent in suit (referring, as I understand, to the filaments described earlier in the patent) says:

> "Substances which are not greatly distorted in "carbonizing may be coated with a non-conduct- "ing, non-carbonizable substance," etc.

Do you know what substances may be used in con- 658
formity with this paragraph, for the purpose of coating the filaments, and how such substance would be applied to the filament?

A. I think that I have an idea of the non-conducting, non-carbonizable substances which might be used for the purpose indicated. I suppose that the substances known in chemistry as the earths might be most suitable, such, for example, as alumina, magnesia, lime, zirconia, etc. These substances might be applied to the filament before carbonization by dusting them on 659
in the form of fine powders or by immersing the filament in a solution or magma of these substances, etc.

196 x-Q. Have you ever known that to be done and useful carbon burners to be produced thereby?

A. A reference to the patent itself will show that the process referred to in the last question is an alternative process, required only in the preparation of a burner in the form of a closely coiled helix. The paragraph previous to the one from which the quotation in the last question is made begins as follows: 660

> "If the carbon thread is liable to be distorted "during carbonization, it is to be coiled between "a helix of copper wire;"

and the paragraph from which the quotation itself is taken, concludes by referring to the

> "non-conducting, non-carbonizable substance "which allows one coil or turn of the carbon to "rest upon and be supported by the other."

Inasmuch as these close spiral burners are no longer

661 necessary when steady currents of electricity are employed, this form of burner has never gone into practical use, and therefore I have never known the process of the patent for making these spiral burners to be used commercially.

197 x-Q. The patent in one of its opening paragraphs says:

> " The invention consists in a light-giving body
> " of carbon wire or sheets," etc.

662 What is the meaning of the term "sheets" in this paragraph?

A. I suppose the word "sheet" to be here used in one of its ordinary acceptations, to wit, meaning a piece of carbon whose thickness is less than its breadth. Thus I find that the specification farther on speaks of carbonizing papers coiled in various ways, which possibly may be what the inventor had in mind.

198 x-Q. And do you understand that the word "strip" used in claim 3 is synonymous with the word
663 "sheet" as above used; if not, what is its meaning?

A. I do not see any reason why the carbon filament of the patent need necessarily have a circular or any other particular form of cross-section. I suppose that a "strip" is wider than it is thick; though exactly where a strip becomes a "sheet" seems to me to be incapable of determination. I think that I should understand the word "strip" in the third claim as a filament of rectangular cross-section; and therefore as the substantial equivalent of the word "sheet" for the pur-
664 poses of this patent.

199 x-Q. The term "Wire" occurs frequently in the patent. Is this term as thus used synonymous with filament?

A. It is my impression that the term "carbon wire" is used in the specification as the synonym of carbon filament; although the word "filament" conveys to my mind the idea of a smaller cross-section than the word "wire."

Adjourned till Saturday, the 23d inst., at 10 A. M.

SATURDAY, November 23d, 1889. 665

Met pursuant to adjournment.

Present--Counsel as before, and the cross-examination of DR. BARKER by GEN. DUNCAN proceeded as follows:

200 x-Q. Do you mean by this, that the two words "filament" and "wire," *as used in the patent*, are synonymous?

A. I cannot, of course, say that, since the patent speaks not only of carbon wire but of platinum wires 666
and of copper wire. It seems to me, however, that the term "carbon wire," as used in line 11 and line 18 of page 2 of the specification, is there used as synonymous with carbon filament.

201 x-Q. Does the term "filament," as used in claims 1 and 2 have a signification that would not include the thing spoken of in the specification as "carbon wire"?

A. It seems to me in general that the term "wire" is broader in its signification than the term "filament." 667
As I have already said, I understand the term "carbon filament" to involve a carbon conductor of a small or thread-like cross-section. Provided, therefore, the "carbon wire" refers to a carbon conductor of a small or thread-like cross-section, which I understand to be the sense in which it is used in the patent, I should say that the term "filament of carbon" of the 1st claim and "carbon filament" of the second included the thing spoken of in the specification as "carbon wire."

202 x-Q. Suppose the burner of a lamp to be made 668
of a "sheet" of carbon or of a "strip" of carbon; what indication do you find in the patent as to the area of the cross-section which such burner must have, beyond the use of the terms "filament" and "wire"?

A. As I have already stated, I do not see any reason in the patent itself for supposing that the patentee intended to restrict the filament to any particular form of cross-section. Indeed the use of the terms "sheets" and "strips" with reference to the carbon conductor seems, I think, to indicate this. Pro-

669 vided, therefore, that the carbon burner of the lamp has a filamentary cross-section, it does not seem to me to be material whether it be square, rectangular or circular in cross-section, or whether it have any other suitable form. Moreover, in my judgment, if the cross-section of the filament be the same, the burner would still be filamentary, whatever the form of its cross-section. All this seems to me to be readily deducible from the patent, although I believe that the patent itself does not refer specifically to the area which the burner of a
670 lamp should have if it were made of a "sheet" or "strip" of carbon, beyond what is involved in the idea of a filamentary burner.

203 x-Q. Suppose an incandescent lamp to have as its burner a piece of carbonized material of four ohms or less total resistance, such burner being inclosed in an exhausted globe made entirely of glass and with the glass of the globe fused around the platinum leading-in wires; would such a lamp embody the invention of either the first or the second claim of the patent in suit, if the
671 cross-section of the burner were of larger area than the cross-section of what you would call a filament?

A. In my 92d cross-answer I said:

> "It is my judgment that the said lamp if it consisted of the combination of a carbon filament "with a receiver made entirely of glass and conductors passing through the glass, from which "receiver the air is exhausted; and further, if the "carbon of which the filament is made is carbon
> 672 "of high specific resistance and if it is made by "giving it its filamentary form before carbonization, the said lamp would be within the claims "of the patent even if its resistance were four "ohms."

If, however, the cross-section of a carbon burner were so large that it could in no sense properly be called a filament; that is to say, if it were so large as not to secure practically any of the important advantages which are set forth in the patent as secured by the filamentary form of the burner, or which flow neces-

sarily from this form, then, as it seems to me, such a 673
lamp provided it were possible to construct it practically and to successfully operate it commercially would not be the lamp contemplated in the first and second claims.

204 x-Q. Is this a negative answer to the question?

A. It is intended to be; that is, under the conditions specified in that answer.

205 x-Q. Was my last question but one an indefinite one; if so, in what respect?

A. A question always seems to me less definite and 674
more liable to misconstruction in proportion as the number of elements which it contains is the more numerous. The first part of the 203d cross-question seemed to me to be substantially the same as the 92d cross-question, and I thought, therefore, that the answer to that question would be applicable, and would thus enable me to eliminate all of the conditions of the question except the last, to wit, the cross-section of the burner, and to answer that part of the question by
itself. I took the liberty of restating what I understood 675
to be the condition involved in the latter part of the said question for the purpose, as I supposed, of making my meaning clear and unambiguous. While, therefore, I might not be disposed to characterize the question as indefinite, I might be permitted to think that the latter part of my answer was expressed more fully and completely, and therefore more definitely.

206 x-Q. Evidently, then, in your restatement of the concluding part of cross-question 203, you undertook to
give your definition of what constitutes a "filament." 676
Is that so?

A. The question speaks of the cross-section of the burner as "of larger area than the cross-section of what "you would call a filament." I suppose, therefore, that my restatement amounted substantially to a restatement of that which I should call a filament.

207 x-Q. Do you mean by this you undertook in your re-statement of the latter part of cross-question 203, to give your *definition* of what you call a filament?

A. I do not exactly understand what the distinction

677 is which the question intends to draw between a "restatement" of that which "I should call a filament" and a "definition" of what I call a filament. In my previous cross-examination I have given as complete a definition of what I understand to be meant in the patent in suit by a "filament" of carbon as I can. Regarding the latter part of my answer to cross-question 203 to be the substantial equivalent of that which I have before stated, I think that I may say that in this sense the restatement of what I should call a filament
678 and a definition of what I should call a filament are substantially the same thing.

208 x-Q. If the carbon burners of one of the old incandescent lamps referred to in the patent in suit were to be inclosed in an air-exhausted globe made entirely of glass with the glass fused directly to the leading-in wires, would such a structure embody the invention of either the first or the second claim of the patent?

679 Objected to as calling for the judgment of the Court, and asking an expression of opinion on a case to arise in future.

A. The patent in suit speaks of the carbon burners of the old incandescent lamps as "rods of carbon of one " to four ohms resistance;" and it states that

> "owing to the low resistance of the lamp the lead-
> "ing wires must be of large dimensions and good
> "conductors and a glass globe cannot be kept
> 680 "tight at the place where the wires pass in and
> "are cemented; hence the carbon is consumed be-
> "cause there must be almost a perfect vacuum to
> "render the carbon stable, especially when such
> "carbon is small in mass and high in electrical re-
> "sistance."

I think, therefore, that the hypothesis of the question is not practicable; and therefore I cannot say what the actual result would be of constructing such a lamp. If, however, the question assumes that the lamp could be so constructed, then I think that the rods of carbon

constituting the burners thereof would not be carbon 681
filaments, and therefore would not embody the invention of the first and second claims.

209 x-Q. In your answer to cross-question 93 you said in substance that a large number of incandescent lamps having a resistance of only four ohms each could be run economically in multiple-arc if the carbons were of high specific resistance and were made by giving them the filamentary form before carbonization. Will you give the details of construction, particularly as regards area of cross-section, length, the character of the 682
carbon used and candle power of the burners which you say could be so used, under the conditions of the aforesaid question?

Adjourned to meet at "The Stratford," Philadelphia, on Monday, 25th inst., at 2 o'clock P. M.

"THE STRATFORD," 683
PHILADELPHIA, November 25, 1889.

Met pursuant to adjournment.

Present—Counsel as before; and the cross-examination of DR. BARKER by GENERAL DUNCAN proceeded as follows:

A. Cross-question 93 is as follows:

> "Could the lamp of the last question be worked
> "in great numbers in multiple arc without the em- 684
> "ployment of main conductors of enormous di-
> "mensions?"

On referring to the 92d cross-question I find that "the lamp of the last question" is "a lamp consisting "of a carbon of four ohms resistance hermetically "closed in a globe 'made entirely of glass' and highly "exhausted."

I think that if Defendant's M Lamp, for example, herein in evidence as an exhibit, had the length of its filament reduced to one-tenth of its present value it would have a resistance, hot, of about four ohms, while

685 the current required to preserve its temperature constant would be unchanged. As the surface, of course, is reduced to one-tenth of its former value, the total radiation, other things being equal, will be similarly reduced, whence the lamp under these conditions would give about one and six-tenths candles.

210 x-Q. In like manner, if Defendant's Tamidine Lamp had its burner reduced in length so that its resistance would be only four ohms, what would its length become and what would be its candle power?

686 A. Assuming, as before, the data given in the stipulation, and assuming the resistance of the carbon of the Tamidine lamp to be twice that of the carbon of Defendant's Zig-Zag Lamp, I find that the length of the filament of the four-ohm lamp would be about one hundred and fifty-four thousandths of an inch in length, and that it would give at the same incandescence and with the same current about four-tenths of a candle.

211 x-Q. In your direct examination, in testifying on the question of infringement, you have said that the
687 invention of the patent in suit is not limited to putting the filament into a spiral or coiled shape, but that "the "description of the patent itself contemplates *any* "*suitable shape*," what did you mean by the term "suitable shape?"

A. I do not know that the word "suitable" is here used in any other than its ordinary meaning. I understand that a thing is suitable for a given purpose when it is so constructed or arranged that it accomplishes the object which it is designed to serve so far as that
688 purpose is concerned. I should think, therefore, that the filamentary burner of an incandescent lamp would be of a suitable shape provided it accomplished in the lamp the objects which it is desirable to secure, so far as the shape is concerned.

212 x-Q. What other shapes does the patent contemplate besides the spiral?

A. I do not know that the patent itself specifically mentions any particular shape for the burner beside the shape of the helix or spiral. This particular form is mentioned, as I suppose, because certain

special advantages are secured by it and it is made 689
the subject of a claim. The specification speaks of "a cotton thread properly carbonized and placed in "a sealed glass globe exhausted to one-millionth of "an atmosphere" as offering "from one hundred to "five hundred ohms resistance to the passage of the "current, and that it is absolutely stable at very high "temperatures." It then goes on to say that "if the "thread be coiled as a spiral and carbonized, or if any "fibrous vegetable substance which will leave a carbon "residue after heating in a closed chamber be so 690
"coiled, as much as two thousand ohms resistance may "be obtained without presenting a radiating surface "greater than three-sixteenths of an inch." Since a distinction is here drawn between the cotton thread, in the first place, and the coiled cotton thread, in the second, it seems to me that the cotton thread first mentioned cannot have been coiled, in the opinion of the patentee, that is to say, any more than might be necessary to bring its ends to the same side of the lamp. Moreover, the patent speaks of "papers coiled 691
"in various ways."

Inasmuch, however, as various shapes had been proposed for the conductors of incandescent lamps before the date at which the application for the patent in suit was filed, it seems to me that the patentee was entitled at that date to use any of these shapes, and if they answered his purpose, did not need to specify them in the patent.

213 x-Q. Would a filament that is absolutely straight be within the invention of the patent, the other ele- 692
ments of the burner being such as are set forth in the patent?

Objected to as calling for a question of law.

A. I do not see any reason why it should not be.

214 x-Q. You have had more or less to say concerning the desirability of using *small* platinum wire for the leading-in conductors of incandescent lamps; can you state what is the maximum size of such wire that

693 can be used for this purpose without endangering the
integrity of the glass?

A. That would depend, I think, upon the expansion
coefficient of the platinum and the glass respectively.
While theoretically this coefficient may be the same
for both substances, in practice this exact equality is
never attained, I believe. Hence it is evident that the
separation of the platinum from the glass along the
surface of junction which is produced by a change of
temperature may vary in amount very greatly in differ-
694 ent cases. Moreover, since the surface of separation
is the greater, the greater the diameter of the platinum
wire employed, it is evident that a given change of
temperature might produce a material separation if the
wire were large, while if the wire be small the separation
might be unimportant. So essential, indeed, is it re-
garded in manufacturing lamps to have the platinum
leading wires small that I understand it is the practice
in place of using a single large wire for the purpose, to
use a number of finer ones.

695 The best result would of course be attained if the
platinum leading-in wires could convey the necessary
current into the lamp without being heated at all. But
as this is impossible, the next best thing is to reduce
the heating to a maximum by carrying as little energy
as possible to the lamp, in the form of current.

If, however, the question calls for the absolute
maximum size of platinum wire which can be sealed
into a lamp and used as a leading wire without
endangering the integrity of the glass, then I have no
696 data on which to base an opinion.

215 x-Q. Was it not well known prior to the year
1878 that platinum was one of the best materials out
of which to make conductors for conveying an electric
current through the walls of an exhausted glass vessel?

A. It was.

216 x-Q. Was it not also well known prior to that
date that an effectual way of making a tight joint
around platinum wires when thus used was to seal the
glass directly to the wires by the fusion of the glass?

A. It was.

217 x-Q. Was it not also well known prior to 1878 697
that if carbon was to be used as the burner of an
incandescent lamp, it was necessary to protect the
burner from the action of the air, and that one of the
ways of doing this was to enclose the carbon in an
exhausted transparent vessel?

A. It was.

218 x-Q. Is it not also a fact that prior to the year
1878, carbonized fibrous material was well known in
the art of electric lighting and had already been used
as the burner of incandescent lamps? 698

A. It was.

219 x-Q. In your deposition given in 1887, in another
suit, then and still pending in the U. S. Circuit Court
for the Southern District of New York, between the
parties to the present suit, and in which there was
involved another of Mr. Edison's patents, viz.: No.
230,255 of July 20, 1880, I find the following questions
and answers:

"41 x-Q. In practice what is the degree of ex-
"haustion used in incandescent electric lamps? 699
"A. I understand that the practice in this
"regard varies considerably. But it is my im-
"pression that the vacuum attained in incandescent
"carbon lamps is on the average not much below
"one hundred thousandth of an atmosphere.
"42 x-Q. Do you know whether it is possible by
"known methods to construct an electric lamp in
"which the enclosing chamber would be of glass
"made in two parts and united otherwise than by
"fusion and capable of maintaining a stable 700
"vacuum as high as the one one-hundred
"thousandth of an atmosphere?
"A. I do not. I think it might be possible to
"construct a lamp in the way indicated, but I do
"not think that a stable vacuum of a one-hundred
"thousandth of an atmosphere could be maintained
"within it.
"43 x-Q. If such a lamp should be constructed,
"and it should be found that the vacuum named
"could not be permanently maintained therein,

701 "would not a person skilled in the art know "perfectly well that this defect in the lamp could "be obviated by uniting the two parts of the glass "wall by fusion ?

"A. I think that such a method of obviating "the defect referred to would readily suggest itself "to a person skilled in the art, provided of course "that the lamp were so constructed as to admit of "thus uniting its parts.

"44 x-Q. Would the same be true as of a date
702 "prior to that of the Edison Patent No. 230,255 ?

"A. I think that it would.

* * * * * *

"101 x-Q. Was it not known long prior to the "date of Edison's invention, as set forth in Patent "230,255, that, if it were desired to unite two "pieces of glass so as to maintain a high stable "vacuum in the chamber formed by their union, "the best way of doing this was to unite the parts "by fusion ?

703 "Objected to as irrelevant and incompetent.

"A. I believe that it was.

"102 x-Q. How long has that been known ?

"Same objection.

"A. I do not know.

"103 x-Q. Has it been known as long as twenty "years ?

"Same objection.

"A. It was known, I believe, more than twenty
704 "years ago, that the best method of preserving "the vacuum in an exhausted glass vessel was to "seal the vessel by a fusion of the glass.

"104 x-Q. If, prior to the date of application for "the Edison Patent No. 230,255, one skilled in the "art had made an incandescent lamp in which the "supporting part and the inclosing part were "united by cement, and on creating a high vacuum "in the globe had found the joint insufficient to "prevent leakage, would he not have known that "such defect might be remedied by hermetically "uniting the two parts by fusion ?

"Same objection.

"A. I think that he would, provided, of course, 705
"that this method of accomplishing the result were "possible."

Do you still hold the views than and thus expressed by you; and would the statements which you then made in response to x-Q. 43 and x-Q. 104, be true as of a date prior to the application for Patent No. 223,-898 (the patent in suit), as well as of a date prior to the application for the patent, No. 230,255, involved in the former suit above referred to ?

706

Objected to as irrelevant and immaterial.

A. I think that I do substantially; although to make my answer complete it seems to me that I should allude to the state of the art at the time referred to. So far as I know, none of the incandescent lamps in use or proposed for use at that date were so constructed as to enable their parts to be united by fusion. In many of them, the lamp chamber was closed by plates of metal; and those in which glass plates were so used were made 707
so thick and heavy that no attempt was made even in view of the knowledge of the time, to unite the glass parts by fusion, or even to seal the conducting wires into the glass in the same way. When, however, Mr. Edison suggested the simple lamp structure of the patent in place of the cumbrous and heavy lamp structures before used, then it became obvious that the method of maintaining a stable vacuum by the fusion of the glass was now entirely practicable, and this method has been since universally resorted to by all 708
manufacturers of incandescent lamps.

These statements would seem to me to be true as of a date prior to the application for the patent in suit.

220 x-Q. In that same deposition I find the following testimony by you in relation to the meaning of the term "incandescent electric lamp :"

"46 x-Q. What, according to your understand-"ing, is an incandescent electric lamp ?

"A. A lamp in which light is produced by the "incandescence of an electrical conductor.

709 "47 x-Q. And what do you mean by the term "'lamp'?

"A. In incandescent lighting I understand that "the word 'lamp' refers to the structure composed "of the incandescent conductor, the leading-in "wires, and the enclosing and supporting parts "taken as a whole.

"48 x-Q. Suppose that such a structure as you "have described in your last answer, though capa-
710 "ble of omitting a bright light when used in the "open air, were in fact constructed for a different "purpose, as, for instance, for the purpose of ap- "plying heat to some one of the cavities of the "human body when introduced therein, would the "structure be a lamp?

"A. It seems to me that it would. In fact in- "candescent electric lamps are used practically, I "believe, for this very purpose."

Do you still agree to the statements then and thus made by you?

711 A. I do; the condition being of course that the structure last referred to be capable of operating as a lamp as well as for the purpose of applying heat.

221 x-Q. I understand you to have said heretofore that the first and second claims of the patent in suit are independent of the *total* resistance of the burner and include series lamps of comparatively low resistance as well as multiple-arc lamps of comparatively high resistance, and that the second claim is independ-
712 ent of the specific resistance of the carbon composing the burner. If these views are correct, what is the meaning of the opening paragraph of the specification as follows:

> "The object of this invention is to produce "electric lamps giving light by incandescence "which shall have high resistance so as to allow "of the practical subdivision of the electric light?"

Objected to as calling for a judicial construction of the patent.

A. It seems to me that it may be possible to interpret the meaning of the words "high resistance" in 713
the paragraph in the question quoted from the specification by means of the quotation itself. It is evidently that kind of high resistance which allows "of the practical subdivision of the electric light." This I referred to in my examination in chief as follows:

> "The filamentary carbon burner also gives "a small radiating surface and a high re- "sistance (and a small mass) per unit of "radiating surface, which conditions per- 714
> "mit a subdivided light to be practically "made and economically employed since they "enable a current of moderate volume to raise the "burner to an economically high temperature; "and the burner when at an economically high "temperature will owing to its small radiating sur- "face give an adequate light, such for example as "that of an ordinary gas jet."

Adjourned for dinner. 715

Resumed at 8 P. M.

222 x-Q. What is the "kind of high resistance" that is referred to in the paragraph quoted above from the specification of the patent—is it high *specific* resistance or is it high *total* resistance?

A. It does not seem to me that it is either of these necessarily. My last answer stated that the high re- 716
sistance which permits a subdivided light to be practically made and economically employed is a high resistance per unit of radiating surface. Since on the one hand a burner may have a high specific resistance and at the same time a low resistance per unit of surface; and on the other a burner may have a low total resistance and at the same time a high resistance per unit of surface, it does not seem to me that the high resistance spoken of is either high specific resistance as such or high total resistance as such.

717 223 x-Q. What kind is it, then, if not one of these two?

Objected to as already specifically answered.

A. The term "high resistance per unit of radiating surface" is a ratio just like the similar expressions "miles per hour" or "dollars per day." If the ratio be a high one, then resistance is said to be high just as the velocity is said to be high in the second case and the
718 wages in the third.

224 x-Q. What is it that determines this ratio which you say is embodied in the expression "high resistance per unit of radiating surface?"

A. Mainly, as it seems to me, the smallness of the radiating surface which characterizes the filamentary burner.

225 x-Q. When the patent, as in its third paragraph, speaks of the "slight surface from which radiation can take place," is reference made to the fact that the
719 burner is in what you call the filamentary form, or rather to the fact that the burner is coiled or arranged in such a manner that light radiation into the surrounding space takes place from a part only of the superficies?

A. The entire paragraph is as follows:

"The invention consists in a light giving body
"of carbon wire or sheets coiled or arranged in
"such a manner as to offer great resistance to the
720 "passage of the electric current and at the same
"time present but a slight surface from which
"radiation can take place."

Further on the specification goes on to state that

"By using a considerable length of carbon wire,
"and coiling it, the exterior, which is only a small
"portion of its entire surface, will form the princi-
"pal radiating surface; hence I am able to raise
"the specific heat of the whole of the carbon and
"thus prevent the rapid reception and disappear-
"ance of the light which on a plain wire is preju-

"dicial, as it shows the least unsteadiness of the 721
"current by the flickering of the light; but if the
"current is steady the defect does not show."

The third claim is for

"A carbon filament or strip coiled and con-
"nected to electric conductors so that only a por-
"tion of the surface of such carbon conductor
"shall be exposed for radiating light."

I conclude therefore that the "slight surface from "which radiation can take place" refers to the exterior 722 surface of the coiled burner "which is only a small por-"tion of its entire surface."

226 x-Q. In answer to question 6 you say that immediately after the issue of the patent in suit

"lamps constructed according to the principles of
"the said invention came into extensive use and
"in enormous numbers."

Do you know how many such lamps were actually put into use during the twelve months succeeding the issue of the patent? 723

A. My impression is that even within that short time a large number of lamps made according to the principles of the patent in suit came into use; certainly a very much larger number than had come into use of all the older forms of lamp taken together. I have never collected together the numerical data on the subject, however, and therefore cannot give the exact number, made by various persons during that time.

227 x-Q. Can you give the length or the cross-sec- 724 tion of the burners made by the owners of the patent during the first year?

A. I cannot as I have never measured them.

228 x-Q. You also say in answer to question 6 that all of the incandescent electric lamps in use to-day with which you are acquainted embody the principles of construction set forth in the patent in suit. What is the largest burner in use in the incandescent lamps with which you are acquainted?

A. I do not know the dimensions of the burners of these large lamps as I have not measured them.

725 229 x-Q. You know it to be a fact, however, do you not, that some of these lamps have burners whose cross-section is many times larger than that of the tar-putty filament described in the patent in suit?

A. I believe that to be the fact.

230 x-Q. If, on measurement, the burner should be found to have a cross-section fifty times that of the said tar-putty filament, would you regard such burner as a filament, and still say that the lamp embodied the invention of the patent in suit?

726 A. That I cannot say, as I have not sufficiently considered the matter.

231 x-Q. Suppose the cross-section of such burner were only ten times that of the tar-putty filament of the patent would such burner then be a filament?

> Objected to, as the former question ought to have been, as calling for the judgment of the Court on a hypothetical case, not before the Court.

727

A. While I do not feel myself competent to express an opinion as to the precise upper limit where a burner ceases to have a small or thread-like cross-section and therefore ceases to be a filament, it seems to me that I have already answered this question since I find that the burner in defendant's M-lamp, herein an exhibit, and which I have called a filament has a cross-section ten times as large as the carbonized tar-putty filament.

232 x-Q. Suppose the burner had a cross-section

728 twenty-five times that of the tar-putty filament of the patent, would it then be a filament?

> Same objection.

A. That I do not know, as I have not considered it.

233 x-Q. Suppose it had a cross-section of twenty times that of the tar-putty filament of the patent, would it be a filament?

A. To this I think I must make the same answer.

234 x-Q. In answer to Q. 6 you have said that all of

the incandescent lamps made by the Edison Company 729
"have been made under the patent in suit and embody "the elements set forth in the first and second claims." Did they not also embody various other inventions patented to Mr. Edison and particularly that set forth in claim 1 of Patent No. 227,229, with which I presume you are familiar?

> Objected to as irrelevant and incompetent and not founded on the examination-in-chief.

A. Yes, as I understand it. 730

235 x-Q. If a carbon filament be substituted for the platinum burner of the lamp shown and described in Patent No. 227,229, would the structure embody the invention of the patent in suit?

> Objected to as being a question of law and not a question for a scientific expert.

A. It seems to me that it would.

236 x-Q. Could the lamp of the patent in suit be 731
made without embodying the invention covered by the first claim of Patent 227,229?

> Same objection.

A. As I understand the question, it does not seem to me that it could.

237 x-Q. Do you not regard claim 1 of Patent 227,229 broader than the claims of the patent in suit?

> Same objection. 732

A. I think that I should so consider it.

238 x-Q. And still would you regard the patent in suit as the fundamental patent?

> Same objection.

A. I think that I should regard the patent in suit as a fundamental patent so far as the question of the use of carbon conductors is concerned, and as compared

733 with subsequent detail patents. But I think that Patent 227,229 is fundamental in the broader sense, since its first claim is independent of the material used for the incandescing conductor.

239 x-Q. Do you, by your answers to x-Qs. 149 and 150, wish to be understood as saying that cotton threads had been carbonized prior to the date of Edison's application for the patent in suit?

A. I do not know that cotton thread, as thread, had actually been so carbonized unless that is implied in
734 the quotation from Gaudin's patent given in my 150th cross-answer.

240 x-Q. What is the number of the British patent of Lane-Fox, referred to by you in answer to question 10?

A. 3988 of 1878.

241 x-Q. What is the number of the English patent of Mr. Edison referred to in your answer to cross-question 13?

A. No. 2402, dated the 17th of June, 1879.

242 x-Q. Did you in the McKeesport suit testify in
735 the language quoted in cross-Q. 125?

A. Yes.

243 x-Q. In the record in the McKeesport suit I find the following as part of your principal deposition:

"7 Q. Please state whether or not you agree
"with the witness, Professor Cyrus F. Brackett,
"who has already testified as an expert for de-
"fendant, in the statements made by him in an-
"swer to question 4 as to the state of the art prior
736 "to the year 1878, bearing upon the invention of
"the patent in suit?

"A. I have read the answer referred to in the
"deposition of Professor Brackett in this case, and
"I agree with him entirely as to the state of the
"art prior to 1878, so far as concerns the inven-
"tion which is the object of the patent in suit. I
"might state in addition, that the use of carbon-
"ized fibrous material for electric lighting pur-
"poses has been familiar to me ever since I had
"any knowledge of the subject of electric lighting.
"As early as 1853 or '54, I learned from my read-

"ing that the pencils which were used for the pro- 737
"duction of the electric light were made of char-
"coal, and perferably of box-wood charcoal. Ac-
"cordingly, following directions which I remem-
"ber to have read, I produced some of the said
"pencils by sawing pieces of box-wood into the
"shape of square rods, placing these in a crucible
"which was afterwards filled with sand and
"heated to the temperature of complete carboniza-
"tion. After cooling I found that the said carbon
"pencils were good conductors of electricity, and 738
"I used them for the purpose of producing electric
"light by incandescence; this incandescence being
"produced at the points of contact of the said
"pencils, the battery employed not having suffi-
"cient tension to allow of their being separated for
"the production of an arc.

"8 Q. In making these charcoal pencils by first
"cutting box-wood to the shape and size desired
"and then carbonizing it, do you understand that
"you were making use of a method well-known in 739
"the art for the production of these pencils at that
"time?

"A. I considered at the time that I was simply
"making use of a well-known method for the pro-
"duction of these pencils, that I was following
"simply an obvious process for that construction
"and that there was no originality in my thus
"making them. This, I might add, is one of the
"methods described for making these pencils in
"the English patent of Slater and Watson, No. 740
"212 of 1852."

Did you so testify and are the statements contained in your said answer still true?

Objected to as immaterial and irrelevant.

A. I did and the statements I believe are true. I might add that "the patent in suit" referred to in the

741 first answer quoted is Sawyer & Man's patent No. 317,676, granted May 12, 1885.

CROSS-EXAMINATION CLOSED.

Adjourned to meet at Mr. Seward's office in New York, on the 26th inst. at 2 P. M.

742

NEW YORK, November 26th, 1889.

Met pursuant to adjournment.

Present—Counsel as before, and the further examination of witnesses herein on behalf of complainant was continued as follows:

CHARLES H. HEELEY, a witness called on behalf of complainant and duly sworn, testifies as follows:

1 Q. What is your name, age, residence and occupa-
743 tion?

A. Charles H. Heeley; 25 years of age; I reside at Newark, New Jersey; I am a bookkeeper for the Edison Lamp Company.

2 Q. How long have you been employed by the Edison Lamp Company and in what capacity?

A. Three years; about a year and a half as assistant bookkeeper, and for the past year and a half as head bookkeeper.

3 Q. Do the books of the Edison Lamp Company,
744 which are in your charge, show the number of incandescent electric lamps manufactured and sold by that company?

A. They do.

4 Q. Please state what such books show from their commencement to and including the year 1888 as to the annual number of lamps manufactured and sold by the company.

Objected to as incompetent and immaterial.

A. The books show that the number of lamps manu- 745
factured and sold by that company from 1881 to 1888, both inclusive, were as follows:

Year.	Lamps Made.	Lamps Sold.
1881.	105,000	34,597
1882.	215,999	202,689
1883.	399,952	333,247
1884.	395,498	370,073
1885.	456,362	432,291
1886.	713,879	623,445
1887.	899,225	826,871
1888.	1,217,934	1,228,117
Total,	4,403,849	4,051,330

746

5 Q. Can you produce a sample of the lamps covered by the entries referred to in your last answer?

A. I can and here do so.

747

(The lamp produced by the witness is offered in evidence by counsel for complainant and the same is marked "Complainant's Exhibit, Edison Lamp, Nov. 26, 1889.")

CROSS-EXAMINATION BY S. A. DUNCAN, ESQ.:

6 x-Q. How long have you been with the Edison Company?

A. Three years. 748

7 x-Q. What were you doing between the year 1880 and the time when you went into the employ of the Edison Company?

A. I was engaged in various occupations, not at all connected with the Edison Company. I worked at the machinist business for about three years, was in the insurance business for about a year. These were my principal occupations during that time.

8 x-Q. Do you of your own knowledge know what

749 was the construction of the incandescent lamps made by the Edison Company in the year 1881?

A. I do not. I knew absolutely nothing about the Edison Company at that time?

9 x-Q. Same question as to the years 1882, '3, '4 and '5?

A. I do not; only that I have seen some of the old samples in our office.

10 x-Q. Samples of what particular years?

A. That would be impossible for me to state. We have
750 a few old lamps in our office that were made previous to my coming with the company, but I do not know in what year they were made.

11 x-Q. Did not the Edison Company keep books prior to the year 1881?

A. They did.

12 x-Q. Are all the lamps that have been made and sold by the Edison Company since you have been with them of the same size as the sample lamp you have produced?

751 A. No, sir.

13 x-Q. Have the lamps that have been made by the Edison Co. during the past three years had burners of different sizes?

A. They vary in size according to the candle-power of the lamp. The actual sizes I know nothing about.

14 x-Q. So far as concerns the thickness of the burner (by which I mean the area of its cross-section), does the sample lamp which you have produced show one of the smaller sizes?

752 A. For that sized lamp, I should say that was the usual sized carbon, but I know really nothing about the carbon—about the size of it.

15 x-Q. It is a fact, is it not, that the company make lamps with burners a good deal thicker and heavier than that of this sample lamp?

A. A good deal is quite a wide range. I know that they make them heavier, but can't say how much heavier.

Re-direct by Mr. Seward: 753

16 Re-d. Q. Do you know the candle-power of the sample lamp produced?

A. Sixteen candle lamp.

17 Re-d. Q. You have spoken of lamps of a higher candle-power; how much higher?

A. To a hundred and fifty candles, and upon special order up to two hundred and fifty.

18 Re-d. Q. Are lamps sold of an intermediate candle-power between sixteen and a hundred and fifty 754 candles?

A. They are.

19 Re-d. Q. Having reference to the lamps of which the candle-power increases from sixteen to two hundred and fifty, when ordered; how is it with glass receivers of such lamps; are they correspondingly increased with the increase of candle-power?

A. They are.

20 Re-d. Q. Having reference to the sample lamp produced; does the company guarantee, or offer to 755 guarantee its duration, and if so, for how long?

Objected to as immaterial.

A. They do not.

21 Re-d. Q. Do you personally know what is the average duration of lamps like the sample?

A. I do not personally know.

Re-cross Examination: 756

22 Re-x-Q. Do the books under your charge show where the different grades or classes of these lamps have been sent by the Edison Co.?

A. They do.

23 Re-x-Q. Also, how many of each size or grade have been made and sold?

A. Not particularly. The information can be gathered from the books, but we have no special record of it.

757 24 Re-x-Q. How many different sizes or kinds of incandescent lamps has the Edison Co. made?

A. It would be impossible for me to say how many kinds they have made. At the present time they make about fifteen sizes.

25 Re-x-Q. I suppose these lamps use fifteen different sizes of burners?

A. From my slight knowledge of their manufacture, I should say they did.

26 Re-x-Q. Can you furnish for the inspection of
758 defendant's counsel a specimen of each of these different sizes or kinds of lamps?

A. I can.

Complainant's counsel says that such an exhibit has already been requested by them, and is in the course of preparation, and will be hereafter introduced as an exhibit in the case.

Re-direct Examination:

759 27 Re-d. Q. What is the lowest candle-power of these fifteen sizes?

A. The smallest lamp that we make is called the Pea-lamp, and I should judge that it would give about one-quarter candle-power.

28 Re-d. Q. The word "Pea" has reference to the apparent size of the glass?

A. Yes.

CHARLES H. HEELEY.

760 Adjourned till Friday, the 29th inst., at 2 o'clock P. M., at the same place.

NEW YORK, November 29, 1889.

Met pursuant to adjournment.

Present—Counsel as before, and the examination of Dr. Barker continued as follows:

Re-direct Examination:

244 Re-d. Q. In your cross-examination you have

been asked questions in which a number of technical 761
terms have been used, and these terms you have adapted in your answers without defining them. In order that definitions of those terms may appear in the record, I will ask you what they mean?

1st. What is meant by "a unit of radiating surface"?

A. In measuring any quantity it is necessary, first, to choose a "unit" in terms of which this quantity can be expressed. This "unit" is generally a definite quantity of the same kind which is adopted as a standard. Thus the "unit" of length may be the 762
foot, the mile, the centimeter or the meter, according as one or the other of these quantities of length be chosen as the term of comparison. So the "unit" of surface may be the square inch or the square centimeter at pleasure. And that fraction of a square inch or a square centimeter which represents the surface of a filament from which the light is radiated is, of course, the total radiating surface. "A unit of radiating surface," therefore, is simply a radiating surface of unit area; *i. e*, of one square inch or one square centi- 763
meter, for example.

245 Re-d. Q. 2d. What is meant by "dividing the light"?

A. By "dividing the light" I understand is meant simply the production of several small units of light from or in place of one large one; as, when in place of one light of a thousand candles, fifty lights of twenty candles or a hundred lights of ten candles each, is produced.

246 Re-d. Q. 3d. Is "multiple arc" synonymous with 764
"in parallel," and if so explain what those phrases mean?

A. I understand that the terms "multiple arc" and "in parallel," as used in the electric science are synonymous. They signify simply that the lamps are placed across the two leading conductors like the rungs of a ladder between its sides. So that there are as many *simultaneous* paths for the current as there are lamps thus placed.

765 247 Re-d. Q. 4th. What is meant by lamps "in series?"

A. The term "lamps in series" refers to the only other method of arranging lamps in a circuit; *i. e.*, consecutively. "Lamps in series" are placed one after the other so that the current flows through them successively.

248 Re-d. Q. 5th. Define the terms "volt," "ohm," "ampere" and "watt?"

A. The "volt" is the unit of electrical *pressure* or
766 electro-motive force. It is approximately the electro-motive force of one cell of Daniell's battery.

The "ohm" is the unit of electrical *resistance*. It is the resistance of a wire of pure copper, for example, one-twentieth of an inch in diameter and two hundred and fifty feet long; or of a copper wire one-thousandth of an inch in diameter and one foot long.

The "ampere" is the unit of electrical *current*. It is the current which flows through a wire of one ohm resistance when there is a difference of electrical press-
767 ure of one volt maintained at its ends. In other words it is approximately the current which flows through a wire of pure copper one foot long and one-thousandth of an inch in diameter when the electro-motive force or pressure between its ends is kept constant at that of a Daniell cell.

The "watt" is the unit of electrical *power* or rate of work. It is the rate at which work is done in a circuit of one ohm resistance when, under a pressure of one volt, an ampere of current constantly flows through it.
768 One horse-power is the equivalent of seven hundred and forty-six watts.

249 Re-d. Q. What is the relative specific resistance of platinum and carbon?

A. My impression is that the specific resistance of carbon may vary from two hundred to seven hundred times that of platinum, according to the character of the carbon employed.

250 Re-d. Q. In your answer to the fourteenth cross Q. you have spoken of platinum lamps made by Mr. Edison in the latter part of 1878. Were those platinum

lamps economically and commercially successful as 769
incandescent lamps?

Objected to as immaterial.

A. I do not understand that the platinum lamps of Mr. Edison which are referred to in the question were economically and commercially successful.

251 Re-d. Q. You have spoken in answer to cross Q. 10 of a patent to St. George-Lane-Fox, dated October, 1878. Have you seen the printed record of the short-
hand writers' notes in the case of The Edison & 770
Swan United Electric Light Company, Limited, vs. Woodhouse & Rawson, tried before Mr. Justice Butt in London in May, 1886? Please look at that record and state therefrom if you can the number of the Lane-Fox patent referred to by you?

A. It appears from the said record that the number of the patent referred to is 3,988.

252 Re-d. Q. Your attention was called on cross-examination to a description of telegraphic sounders
arranged in multiple arc, and also to a similar arrange- 771
ment of platinum coils for igniting gas. Could you economically and practically substitute the wires of the sounders or the platinum coils of the gas-lighting devices for the filamentary carbons shown in complant's exhibits of defendant's lamps and described and claimed in the patent in suit?

A. You could not.

253 Re-d. Q. You stated in answer to cross-question
90 that a current of two amperes might possibly be a 772
"moderate" current for incandescent lamps. Did you mean to be understood by that answer as holding the opinion that two amperes would be the upper limit of a moderate current for this purpose?

A. I did not. I did not intend in answer to cross-question 90, or in answer to cross-question 89, to fix any upper limit within ten amperes for what would, in my opinion, be a moderate current.

773 RE-CROSS-EXAMINATION:

254 Re-x-Q. Do you mean by your last answer to indicate that, in your opinion, a current of more than five amperes, but less than ten, would be a "moderate" current for incandescent lamps?

A. I do not. I intend simply to say that, in my judgment, it is not possible to fix any upper limit within ten amperes for what would be a moderate current, in the absence of any experimental data upon the
774 subject.

255 Re-x-Q. In Re-d. Q. 249, you speak of the specific resistance of carbon as being from two hundred to seven hundred times that of platinum. What kinds of carbon, if you know, have this lower specific resistance and what the higher?

A. I did not have in mind any special varieties of carbon in answering that question. Wilde, in speaking of the carbons used in the Lodyguine lamp, gives the specific resistance of this carbon as two hundred and
775 fifty times that of platinum, and my impression is that the more porous and less dense carbons produced by carbonization might be two or three times this or even more.

256 Re-x-Q. Do you understand that the high specific resistance of carbon as compared with platinum, was one of the reasons why carbon was used in the old incandescent lamps referred to in the patent in suit?

A. I do not remember ever to have seen it so stated, and my impression is that this was not the reason, in
776 view of the fact that the tendency seems to have been toward low resistance. It seems to me that the chief reason for using carbon in preference to platinum was its infusibility.

257 Re-x-Q. Do you mean by this that, in your judgmen, the high relative specific resistance of carbon had *nothing* to do with its selection for use in those old lamps?

A. I mean simply that, in my judgment, the high specific resistance of carbon relative to platinum was not *the* reason for thus selecting it; whether it was *a*

reason I cannot say, as I have never seen it referred to, 777
so far as I remember.

GEORGE F. BARKER.

By stipulation between counsel the complainant's time to close its *prima facie* testimony is extended to include the session just now closed.

Plaintiff states that in order that Court and counsel may have for easy reference the judicial literature appertaining to the patent in suit,
it will print at the end of its *prima facie* case the 778
opinion of Mr. Justice Bradley in the Consolidated Electric Light Co. vs. McKeesport Light Co.; the judgment of Mr. Justice Butt in the case of The Edison and Swan United Electric Light Company, Limited, vs. Woodhouse and Rawson, delivered at London on the 20th of May, 1886; the judgment of Lord Justices Cotton, Bowen and Fry delivered in London on the 31st of January, 1887, on the appeal to the Court of
Appeal from the aforesaid judgment of Mr. 779
Justice Butt, and also judgments of Lord Justices Cotton, Lindley and Bowen delivered at London on the 18th of February, 1889, on the appeal to the Court of Appeal in the case of the Edison and Swan United Electric Light Co. vs. Holland, and also the decision in the German and English language of the Imperial Patent Office of Germany, in the case of The Swan Electric Light Company, Limited, of London,
plaintiff, vs. The Edison Electric Light Co. of 780
Europe, Limited, of New York, defendant, delivered at its session of January 24th, 1884; also the decision in the German and English language of the Royal General Court of Justice of Berlin, announced March 9th, 1885, in the case of Thomas Alva Edison, Engineer of Menlo Park, New Jersey, U. S. A., plaintiff, vs. the firm Naglo Brothers and the owners thereof, 1 Emile Naglo, manufacturer; 2. William Naglo, manufacturer,

781 of Berlin, defendants, together with the exhibits in such decision referred to.

Defendant's counsel objects to the foregoing statement or notice of complainant's counsel in regard to the so-called "judicial literature appertaining to the patent in suit," first and generally, as incompetent, irrelevant and immaterial; secondly and specially, on the ground that the said notice is in no sense evidence of any of the
782 facts impliedly set up therein, and contains no matter properly constituting a part of this record; thirdly, because complainant has no right to introduce into its printed record, to be submitted to the Court on the hearing, matter which forms no part of the record proper; and, fourthly, because the alleged judgments, opinions and exhibits of the specific foreign tribunals are at best only selected parts of the so-called "judicial literature" of the patents to which they relate,
783 and therefore are calculated to convey false and erroneous impressions in regard to such "judicial literature" as a whole. Accordingly defendant's counsel gives notice that he will move to expunge the matter hereby objected to, and to strike from the printed record the documents which, by the aforesaid notice, it is proposed to print at the end of complainant's *prima facie* proofs, the said documents having been neither authenticated nor offered in evidence.

784 Complainant's counsel gives notice that complainant's *prima facie* case is closed.

Complainant's Exhibit Patent in Suit. 785
Oct. 15, 1889. S. M. H., Exr.

THE EDISON ELECTRIC LIGHT CO. vs. THE UNITED STATES ELECTRIC LIGHTING COMPANY.	No. 3445.

786

[2-175.]

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE.

To all Persons to whom these Presents shall come, Greeting: 787

This is to certify that the annexed is a true copy from the Records of this Office, of the Letters Patent granted Thomas A. Edison, January 27, 1880, Number 223,898, for Improvement in Electric Lamps.

In testimony whereof, I, ROBERT J. FISHER, Acting Commissioner of Patents, have caused the seal of the Patent
Office to be affixed this 18th day of 788
June, in the year of our Lord one thousand eight hundred and eighty-nine, and of the Independence of the United States the one hundred and thirteenth.

[SEAL.]

ROBERT J. FISHER,
Acting Commissioner.

789 No. 223,898. (2-155.)

THE UNITED STATES OF AMERICA.

To all to whom these Presents shall come:

Whereas, Thomas A. Edison, of Menlo Park, New Jersey, has presented to the Commissioner of Patents a petition praying for the grant of Letters Patent for
790 an alleged new and useful Improvement in Electric Lamps, a description of which invention is contained in the Specification, of which a copy is hereunto annexed and made a part hereof, and has complied with the various requirements of law in such case made and provided; and

Whereas, upon due examination made, the said claimant is adjudged to be justly entitled to a patent under the law;

Now, therefore, these Letters Patent are to grant
791 unto the said Thomas A. Edison, his heirs or assigns for the term of seventeen years from the twenty-seventh day of January, one thousand eight hundred and eighty, the exclusive right to make, use and vend the said invention throughout the United States and the Territories thereof.

In testimony whereof, I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the
792 City of Washington this twenty-seventh day of January, in the year of our Lord one thousand eight hundred and eighty, and of the Independence of the United States of America the one hundred and fourth.

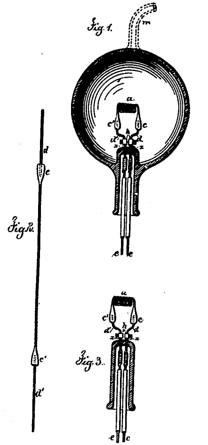
[SEAL.]

A. Bell.
Acting Secretary of the Interior.

Countersigned:
H. E. Paine,
Commissioner of Patents.

T. A. EDISON.
Electric-Lamp.

No. 223,898. Patented Jan. 27, 1880.



Witnesses
Chas H Smith
Geo T Pinckney

Inventor
Thomas A. Edison
for Lemuel W. Serrell
atty

UNITED STATES PATENT OFFICE. 793

THOMAS A. EDISON, OF MENLO PARK, NEW JERSEY.

ELECTRIC LAMP.

Specification forming part of Letters Patent No. 223,898, dated January 27, 1880.

Application filed November 4, 1879. 794

To all to whom it may concern:

Be it known that I, THOMAS ALVA EDISON, of Menlo Park, in the State of New Jersey, United States of America, have invented an Improvement in Electric Lamps, and in the method of manufacturing the same, (Case No. 186,) of which the following is a specification.

The object of this invention is to produce electric
lamps giving light by incandescence, which lamps shall 795
have high resistance, so as to allow of the practical subdivision of the electric light.

The invention consists of a light-giving body of carbon wire or sheets coiled or arranged in such a manner as to offer great resistance to the passage of the electric current, and at the same time present but a slight surface from which radiation can take place.

The invention further consists in placing such burner of great resistance in a nearly-perfect vacuum, to pre-
vent oxidation and injury to the conductor by the at- 796
mosphere. The current is conducted into the vacuum-bulb through platina wires sealed into the glass.

The invention further consists in the method of manufacturing carbon conductors of high resistance, so as to be suitable for giving light by incandescence, and in the manner of securing perfect contact between the metallic conductors or leading-wires and the carbon conductor.

Heretofore light by incandescence has been obtained from rods of carbon of one to four ohms resistance,

797 placed in closed vessels, in which the atmospheric air has been replaced by gases that do not combine chemically with the carbon. The vessel holding the burner has been composed of glass cemented to a metallic base. The connection between the leading-wires and the carbon has been obtained by clamping the carbon to the metal. The leading-wires have always been large, so that their resistance shall be many times less than the burner, and, in general, the attempts of previous persons have been to reduce the resistance of the
798 carbon rod. The disadvantages of following this practice are that a lamp having but one to four ohms resistance cannot be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions; that, owing to the low resistance of the lamp, the leading-wires must be of large dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires pass in and are cemented; hence the carbon is consumed, because there must be almost a perfect vacuum to render the carbon
799 stable, especially when such carbon is small in mass and high in electrical resistance.

The use of a gas in the receiver at the atmospheric pressure, although not attacking the carbon, serves to destroy it in time by "air-washing," or the attrition produced by the rapid passage of the air over the slightly-coherent highly-heated surface of the carbon. I have reversed this practice. I have discovered that even a cotton thread properly carbonized and placed in a sealed glass bulb exhausted to one-millionth of an at-
800 mosphere offers from one hundred to five hundred ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures; that if the thread be coiled as a spiral and carbonized, or if any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber be so coiled, as much as two thousand ohms resistance may be obtained without presenting a radiating-surface greater than three-sixteenths of an inch; that if such fibrous material be rubbed with a plastic composed of lamp-lack and tar, its resistance may be made high or low,

according to the amount of lamp-black placed upon it; 801
that carbon filaments may be made by a combination of tar and lamp-black, the latter being previously ignited in a closed crucible for several hours and afterward moistened and kneaded until it assumes the consistency of thick putty. Small pieces of this material may be rolled out in the form of wire as small as seven-one-thousanths of an inch in diameter and over a foot in length, and the same may be coated with a non-conducting non-carbonizing substance and wound on a bobbin, or as a spiral, and the tar carbonized in a 802
closed chamber by subjecting it to high heat, the spiral after carbonization retaining its form.

All these forms are fragile and cannot be clamped to the leading-wires with sufficient force to insure good contact and prevent heating. I have discovered that if platinum wires are used and the plastic lamp-black and tar material be molded around it in the act of carbonization there is an intimate union by combination and by pressure between the carbon and platina, and nearly perfect contact is obtained without the necessity 803
of clamps; hence the burner and the leading-wires are connected to the carbon ready to be placed in the vacuum-bulb.

When fibrous material is used the plastic lamp-black and tar are used to secure it to the platina before carbonizing.

By using the carbon wire of such high resistance I am enabled to use fine platinum wires for leading-wires, as they will have a small resistance compared to the burner, and hence will not heat and crack the sealed 804
vacuum-bulb. Platina can only be used, as its expansion is nearly the same as that of glass.

By using a considerable length of carbon wire and coiling it the exterior, which is only a small portion of its entire surface, will form the principal radiating-surface; hence I am able to raise the specific heat of the whole of the carbon, and thus prevent the rapid reception and disappearance of the light, which on a plain wire is prejudical, as it shows the least unsteadiness of

805 the current by the flickering of the light; but if the current is steady the defect does not show.

I have carbonized and used cotton and linen thread, wood splints, papers coiled in various ways, also lamp-black, plumbago, and carbon in various forms, mixed with tar and kneaded so that the same may be rolled out into wires of various lengths and diameters. Each wire, however, is to be uniform in size throughout.

If the carbon thread is liable to be distorted during
806 carbonization it is to be coiled between a helix of copper wire. The ends of the carbon or filament are secured to the platina leading-wires by plastic carbonizable material, and the whole placed in the carbonizing-chamber. The copper, which has served to prevent distortion of the carbon thread, is afterward eaten away by nitric acid, and the spiral soaked in water, and then dried and placed on the glass holder, and a glass bulb blown over the whole, with a leading-tube for exhaustion by a mercury-pump. This tube, when a high
807 vacuum has been reached, is hermetically sealed.

With substances which are not greatly distorted in carbonizing, they may be coated with a non-conducting non-carbonizable substance, which allows one coil or turn of the carbon to rest upon and be supported by the other.

In the drawings, Figure 1 shows the lamp sectionally. *a* is the carbon spiral or thread. *c c'* are the thickened ends of the spiral, formed of the plastic compound of lamp-black and tar. *d d'* are the platina wires.
808 *h h* are the clamps, which serve to connect the platina wires, cemented in the carbon, with the leading-wires *x x*, sealed in the glass vacuum-bulb. *e e* are copper wires, connected just outside the bulb to the wires *x x*. *m* is the tube (shown by dotted lines) leading to the vacuum-pump, which, after exhaustion, is hermetically sealed and the suplus removed.

Fig. 2 represents the plastic material before being wound into a spiral.

Fig. 3 shows the spiral after carbonization, ready to 809
have a bulb blown over it.

I claim as my invention—

1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires, as set forth.

2. The combination of carbon filaments with a receiver made entirely of glass and conductors passing through the glass, and from which receiver the air is exhausted, for the purposes set forth. 810

3. A carbon filament or strip coiled and connected to electric conductors so that only a portion of the surface of such carbon conductors shall be exposed for radiating light, as set forth.

4. The method herein described of securing the platina contact wires to the carbon filament and carbonizing of the whole in a closed chamber, substantially as set forth.

Signed by me this 1st day of November, A. D. 1879.

Thomas A. Edison. 811

Witnesses:

S. L. Griffin,
John F. Randolph.

Correction in Letters Patent No. 223,898.

812

Department of the Interior,
United States Patent Office,
Washington, D. C., December 18, 1883.

In compliance with the request of the party in interest, Letters Patent No. 223,898, granted January 27, 1880, to Thomas A. Edison, of Menlo Park, New Jersey, for an improvement in "Electric Lamps," is hereby limited so as to expire at the same time with the patent of the following named, having the shortest time to run, viz.: British patent dated November 10, 1879,

813 No. 4,576; Canadian patent dated November 17, 1879, No. 10,654; Belgian patent dated November 29, 1879, No. 49,884; Italian patent dated December 6, 1879, and French patent dated January 20, 1880, No. 133,756.

It is hereby certified that the proper entries and corrections have been made in the files and records of the Patent Office.

This amendment is made that the United States Patent may conform to the provisions of Section 4887 of the Revised Statutes.

814 BENJ. BUTTERWORTH,
Commissioner of Patents.

Approved:
M. L. JOSLYN,
Acting Secretary of the Interior.

815

816

Complainant's Exhibit Assignment from Edison to Complainant, October 15th, 1889. S. M. H., Exr. 817

EDISON E. L. Co.
vs. No. 3445.
U. S. E. L. Co.

818

[2—175.]

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons whom these presents shall come, greeting:

This is to certify that the annexed is a true copy from the records of this office of an instrument in 819
writing executed by Thomas A. Edison, February 12, 1880, and recorded in Liber C 25, page 302.

Said record has been carefully compared with the original, and is a correct transcript of the whole thereof.

In testimony whereof I, Robert J. Fisher, Acting Commissioner of Patents, have caused the seal of the Patent Office to be affixed this 18th day of
[SEAL.] June, in the year of our Lord one 820
thousand eight hundred and eighty-nine, and of the Independence of the United States the one hundred and thirteenth.

ROBERT J. FISHER,
Acting Commissioner.

Liber C 25, p. 302.

WHEREAS I, Thomas Alva Edison, of Menlo Park, in the State of New Jersey, have obtained Letters Patent

821 of the United States for the inventions or improvements, and numbered and dated as hereafter described.

Now, in consideration and execution of agreements heretofore made by me with the Edison Electric Light Company, a corporation created and existing under the laws of the State of New York, and of one dollar to me paid by the said company, the receipt whereof I hereby acknowledge, I, the said Thomas Alva Edison, have sold, assigned and transferred, and by these presents do sell, assign and transfer to the Edison Electric Light
822 Company all the right, title and interest whatsoever which I have in and to the inventions, improvements and Letters Patent of the United States, more particularly described as follows, to wit:

1. An improvement in electric light as set forth in the specification forming part of Letters Patent of the United States numbered 214,636, dated April 22d, 1879, and all my right, title and interest whatsoever in and to the said Letters Patent No. 214,636.

2. An improvement in thermal regulators for electric
823 lights as set forth in the specification forming part of Letters Patent of the United States numbered 214,637, dated April 22d, 1879, and all my right, title and interest whatsoever in and to the said Letters Patent No. 214,637.

3. An improvement in electric lighting apparatus as set forth in the specification forming part of Letters Patent of the United States numbered 218,866, dated August 26th, 1879, and all my right, title and interest whatsoever in and to the said Letters Patent No. 218,-
824 866.

4. An improvement in electric light as described in a specification forming part of Letters Patent No. 219,628 dated September 16th, 1879, and all my right, title and interest whatsoever in and to said Letters Patent No. 219,628.

5. An improvement in magnetic electric machines as set forth in the specification forming part of Letters Patent of the United States numbered 218,166 dated August 5th, 1879, and all my right, title and interest whatsoever in and to the said Letters Patent No. 218,166.

6. An improvement in apparatus for electric lights as 825
set forth in the specification forming part of Letters Patent of the United States numbered 218,167 dated August 5th, 1879, and all my right, title and interest whatsoever in and to said Letters Patent No. 218,167.

7. An improvement in dynamo-electric machines as set forth in a specification forming part of Letters Patent of the United States No. 219,393 dated September 9th, 1879, and all my right, title and interest whatsoever in and to said Letters Patent No. 219,393.

8. An improvement in magneto-electric machines as 826
set forth in a specification forming part of Letters Patent of the United States No. 222,881 dated December 23d, 1879, and all my right, title and interest whatsoever in and to said Letters Patent No. 222,881.

9. An improvement in electric lamps as set forth in a specification forming part of Letters Patent No. 223,898 dated January 27, 1880, and all my right, title and interest in and to said Letters Patent No. 223,898.

10. An improvement in electric lighting apparatus as set forth in a specification forming part of Letters 827
Patent No. 224,329 dated February 10, 1880, and all my right, title and interest in and to said Letters Patent No. 224,329.

The same to be held and enjoyed by the said Edison Electric Light Company, its successors and assigns, for its and their own use and behoof, to the full end of the terms of each of said Letters Patent respectively, and of all extensions and renewals of any of them as fully and entirely as the same would have been held and enjoyed by me had this sale and assignment not been 828
made.

In testimony whereof, I have hereto set my hand and seal this twelfth (12) day of February in the year one thousand eight hundred and eighty.

THOMAS A. EDISON. [SEAL.]

In presence of
S. L. GRIFFIN,
CHAS. BATCHELOR.

Recorded Feb. 24, 1880.
E. C. C.,
E. L. L.

829 STATE OF NEW YORK, }
City and County of New York, } ss.:

We, Tracy R. Edson, James H. Banker, Norvin Green, Robert L. Cutting, Jr., Grosvenor P. Lowrey, Robert M. Gallaway, Egisto P. Fabbri, George R. Kent, George W. Soren, Charles F. Stone, all of the City of New York, in the County and State of New York; and Nathan G. Miller, of Bridgeport, in the State of Connecticut; and Thomas A. Edison, of Menlo
830 Park, in the State of New Jersey; and George S. Hamlin, of Rutherford Park, in the State of New Jersey, being desirous of forming a corporation pursuant to and in conformity with the Act of the Legislature of the State of New York passed February 17th, 1848, entitled "An Act to authorize the formation of corporations for manufacturing, mining, mechanical or chemical purposes," and the various acts of said Legislature additional thereto or amendatory thereof, have associated ourselves together for the purposes aforesaid,
831 and in pursuance of the requirements of said acts do make, sign and acknowledge this certificate, and do hereby certify as follows:

FIRST. The corporate name of the said company is "THE EDISON ELECTRIC LIGHT COMPANY."

SECOND. The objects for which the said company is formed are to own, manufacture, operate and license the use of various apparatus used in producing light,
832 heat or power by electricity.

THIRD. The amount of the capital stock of the said company is three hundred thousand dollars.

FOURTH. The number of shares of which the said capital stock of the company shall consist is three thousand.

FIFTH. The term of the existence of said company is fifty years from the fifteenth day of October, one thousand eight hundred and seventy-eight.

SIXTH. The number of the Trustees of the said company shall be thirteen, and the names of those who shall manage the concerns of the company for the first year are: 833

TRACY R. EDSON,	EGISTO P. FABBRI,
JAMES H. BANKER,	GEORGE R. KENT,
NORVIN GREEN,	GEORGE W. SOREN,
ROBERT L. CUTTING, JR.,	CHARLES F. STONE,
GROSVENOR P. LOWREY,	NATHAN G. MILLER,
ROBERT M. GALLAWAY,	THOMAS A. EDISON,

GEORGE S. HAMLIN. 834

SEVENTH. The names of the city and county in which the operations of said company shall be carried on are the City of New York and County of New York, in the State of New York.

In witness whereof, we have hereunto set our hands this sixteenth day of October, one thousand eight hundred and seventy-eight.

T. A. EDISON,	G. P. LOWREY,
TRACY R. EDSON,	N. G. MILLER,
JAS. H. BANKER,	ROBT. M. GALLAWAY, 835
NORVIN GREEN,	G. W. SOREN,
R. L. CUTTING, JR.,	C. F. STONE,
G. R. KENT,	G. S. HAMLIN,

E. P. FABBRI.

STATE OF NEW YORK, } 836
City and County of New York, } ss.:

On this sixteenth day of October, one thousand eight hundred and seventy-eight, before me personally came Tracy R. Edson, James H. Banker, Norvin Green, Robert L. Cutting, Jr., Grosvenor P. Lowrey, Robert M. Gallaway, Egisto P. Fabbri, Nathan G. Miller, George R. Kent, George W. Soren, Charles F. Stone, Thomas A. Edison and George S. Hamlin, to me known to be the individuals described in and who executed the forego-

837 ing certificate, and they severally before me signed the said certificate and acknowledged that they executed the same.

[SEAL.]

CHARLES ROTH,
Notary Public (67),
N. Y. County.

STATE OF NEW YORK,
838 City and County of New York, } SS.:

I, EDWARD F. REILLY, Clerk of the said City and County and Clerk of the Supreme Court of said State for said County, do certify that I have compared the preceding with the original certificate of incorporation of the Edison Electric Light Company on file in my office, and that the same is a correct transcript therefrom and of the whole of such original.

Endorsed: Filed 17th Oct., 1878.

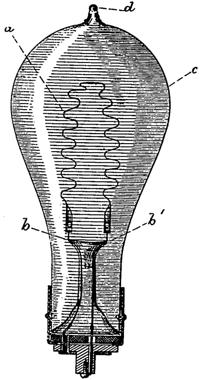
839 In witness whereof, I have hereunto subscribed my name and affixed my official seal this 13th day of Dec., 1889.

[SEAL.]

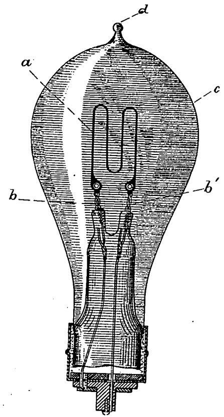
EDWARD F. REILLY,
Clerk.

840

Edison E L Co v U S E L Co } no 3445
Complainants exhibit
Bonkers drawing of
Defendants Zigzag and
Jasmidine Lamps
Oct 21 1889
E M H
Exr



Edison E L Co } no 3445
vs
U S E L Co
Complainants exhibit
Barker drawing of
Defendants Alt lamp
Oct 21 1889
J.M.H. Exr



JUDICIAL LITERATURE APPERTAINING TO THE PATENT IN SUIT.

DECISIONS OF THE IMPERIAL PATENT OFFICE AND THE ROYAL GENERAL COURT OF JUSTICE OF BERLIN, 1884 AND 1885.

JUDGMENTS OF THE ENGLISH COURTS, 1886, 1887 AND 1889.

OPINION OF MR. JUSTICE BRADLEY OF THE UNITED STATES CIRCUIT COURT, OCTOBER 5, 1889.

(TRANSLATION, P. 248.) 849

In Sachen

der Swan United Electric Light Company Limited, zu London, Klägerin

wider

die Edison Electric Light Company of Europe, Limited, zu New-York, Beklagte,

hat die Abtheilung VII des Kaiserlichen Patent-Amtes 850
in der Sitzung vom 24. Januar 1884, an welcher Theil genommen haben:

Dr. Stüve, Präsident,
Rommel, ständiges Mitglied,
W. Wedding, Brix, Dr. Kerl, } nicht ständige Mitglieder,

nach mündlicher Verhandlung dahin entschieden, dass Klägerin mit ihrem Antrage:

das Patent No. 12174 auf „Neuerungen an elek- 851
trischen Lampen" ganz, bezüglich theilweise für nichtig zu erklären,

abzuweisen und in die Kosten des Verfahrens zu verurtheilen.

GRÜNDE:

Dem Thomas Alva Edison zu Menlo-Park (New-Jersey, U. S. A.) Rechtsvorgänger der Beklagten,
ist auf seine, am 26. November 1879 eingegangene 852
Anmeldung das vom folgenden Tage an giltige, deutsche Reichs-patent No. 12174, auf „Neuerungen an elektrischen Lampen" ertheilt worden.

Die Patentansprüche lauten:

1. Eine elektrische Lampe, die durch Weissglühen Licht giebt, und in der Hauptsache aus Kohlenfaser von grossem Widerstande besteht, welche, wie beschrieben dargestellt, und mit metallischen Drähten verbunden ist;

[NOT FILMED: PAGES 214-247]

989 **DECISION OF THE IMPERIAL PATENT OFFICE.**

In the case of
The Swan Electric Light Company, Limited, of London,
Plaintiff,

against

The Edison Electric Light Company, of Europe,
990 Limited, of New York, Defendant.

Part VII. of the Imperial Patent Office, in its session of January 24th, 1884, in which participated:

Dr. Stüve, President.
Rommel, permanent member.
W. Wedding, Boix, Dr. Kerl, } not permanent members,

991 after verbal hearing has decided to the effect that the motion of plaintiff to annul the Patent No. 12,174 for "Improvements in electric lamps," wholly or in part, is to be denied, and that he is to be sentenced to pay the costs of the proceeding.

REASONS:

To Thomas Alva Edison, of Menlo Park (New Jersey, U. S. A.), predecessor in law of the defendant, has
992 been issued, upon his application received November 26th, 1879, and going into effect on the day following, the German Patent No. 12,174 for "Improvements in Electric Lamps."

The patent claims are as follows:

1. An electric lamp, which gives light by incandescence, and in the main consists of a filament of carbon of high resistance which is made as described and secured to metallic wires.

2. A filament or strip of carbon fibres, wound into spiral shape in such a way that only a part of the surface of the carbon radiates light. 993

3. The method herein described of securing the platina contact wires to the carbon filament and carbonizing the whole in a closed chamber, as set forth.

Plaintiff makes the principal motion to declare all three patent claims to be null and void or eventually* that claims No. 1 and No. 3 combined will read as follows:

"In an electric lamp which gives light by incan- 994
"descence the employment of carbon conductors
"consisting of a mixture of lampblack and tar,
"and fastened with the same material during car-
"bonization to the platina contact wires."

For claim No. 2 plaintiff petitions in its contingent motion for the following form:

"The employment of a filament or strip of car-
"bon fibres which is made as specified in claim
"No. 1, and coated with non-conducting, non-car-
"bonizable material and wound in spiral shape so 995
"that only part of the surface radiates light."

The following reasons are set forth by plaintiff in support of this request:

In the preliminary examination of Edison's now contested patent, one of applicant's claims, the most important, has been crossed off, while at the same time the specification filed by him has apparently been embodied unchanged in Patent No. 12,174. The result is an un-

996

* A literal rendering of the Latin word "eventualiter." The idea of the plaintiff in this case was to petition the Patent Office to annul the Edison patent, or (as an alternative) if the evidence was not in the opinion of the Office sufficient to justify this, to restrict and limit its scope. Hence the motion was in two divisions, the "principal," and the "alternative," "contingent," "provisional," "conditional," or "substitute;" all these words giving with greater or less clearness the idea conveyed in the original by "eventualiter." Where this word hereafter occurs in this decision I have therefore rendered it "contingent."—Translator.

997 certainty about the extent of the patent, and this advantage is taken by the present owners in order to give the patent much too broad an interpretation. The defendant lays claim as subject to the patent not the contents of the patent claims but those details designated as inventions in the first five paragraphs of the specification. But these details were not novel at the time of application for the contested patent as is evinced by the English patents:

998 (*a*) No. 10,919 of the year 1845.
(*b*) No. 119 of the year 1853.
(*c*) No. 4626 of the year 1878.

In the patent cited under (*a*) bearing the title, "Improvements in obtaining light by electricity," an electric lamp is secured to Edward A. King in which, for the purpose of producing light by means of an electric current, "continuous metallic and carbon conductors" are employed in exhausted glass globes.

King also employs in these lamps platina conducting
999 wires and divides the electric light as is shown on page 3, line 34 of the English specifications. King further describes in line 15 the employment of conductors in the form of "leaves."

[These "leaves" were platina.—Translator.]

According to the specification of the patent cited under (*b*), the holder employed as far back as 1853, a mixture of lampblack and tar for the production of carbon conductors, and like Edison, coated copper
1000 wires with this mixture.

It further follows, from page 4, lines 30 to 32 of this specification, that the method of producing carbon fibres from a mixture of lampblack and tar, claimed by Edison as an invention, was known to Binks at that time.

In the English Patent No. 4626 of 1878, Lane-Fox describes how he used strips (leaves) or wires in spiral form (also called "scrolls" by Edison) how he connects both ends of them to platina wires fused in the glass, and how he obtains the device which Edison designates

as the vacuum globe. Lane-Fox also at that time 1001
connected the platina wires to good conductors on the outside. Furthermore he has given the most comprehensive rules for the division of the electric light, and in his specification No. 1122 of the year 1879, he describes an electric lamp which shows all the peculiarities of the Edison Lamp.

Concerning the Claim No. 2 of the contested patent, plaintiff bases its demand for the nullification of the same on the one hand on the insufficient description in
the patent, and on the other hand on the publication of 1002
the above-mentioned English Patent No. 4626 of 1878, from which is quoted:

"When platinum, iridium, iron or other metal is "used either pure, or alloyed with some other ma-"terial or materials and either plain or covered "with some suitable material, such as powdered "asbestos, magnesia or a vibreous substance, I "prefer to coil a long strip or wire into the form
"of a spiral and to attach the two ends to plati- 1003
"num wires fixed side by side."

[The German manuscript quotes this paragraph in English, as here literally copied. "Vibreous" should be "Fibrous."—Translator.]

It was therefore the intention of Lane-Fox as well as of Edison to produce by means of the long spiral the highest possible resistance in the electrical conductor and to avoid at the same time the consequences of
unnecessarily great loss of heat. 1004

But if it should be recognized as a novel invention, that Edison has coated spirally shaped carbon wires with non-conducting material, while Lane-Fox has selected metal or metal-alloys as conductors, it is to be remarked that the latter also describes carbon conductors in his specification on page 2, line 15. Patent protection cannot therefore remain in force merely for carbon conductors coated with non-conducting material nor even for the spiral shape of the carbon conductor, but at the most for a carbon conductor made

1005 from material as described and in combination with the method to effect the contact between the platina wires and the carbon conductor during carbonization. This limitation has found expression in the contingent motion to Claim No. 2.

The defendant opposes the motion for nullification. It explains in the first place the cause which led to the striking out of the fourth claim asked for by its predecessor in law Edison, and denies that it gives to its patent an interpretation beyond the limits of the
1006 patent claims granted. If, however, this should be so, it would nevertheless be no cause for proceedings for nullification. Going into details, defendant denies that it claims as patented to it, merely an electric lamp that gives light by incandescence. Claim No. 1 rather calls for an electric incandescent lamp which consists in the main of carbon fibre of high resistance.

Nor does defendant make a general pretension for "a burner of high resistance," but only for a burner consisting of carbon fibre of high resistance.

1007 In the combination "burner of high resistance" the words "of high resistance" would be without special significance, for, as is known, the resistance of a carbon conductor varies according to the proportion of its cross-section to its length.

Furthermore, the employment of the platina wires fused into the glass and the connection effected by them between the metallic conducting wires and the carbon conductors are not claimed to be an independently patented element of the lamp although the same forms
1008 a necessary constituent part of the whole invention. Finally, the method of producing carbon conductors which have such a high resistance that they are suitable for electric lighting by incandescence is not generally set forth as an object of invention, but a *specified* mode of production which possesses the distinguishing feature that it permits the subdivision of the electric current at pleasure, and hence the throwing into circuit any desired number of lamps.

Defendant thereupon gives a historical review of the

origin of Edison's invention, and then sets forth the 1009
contents and meaning of the separate patent claims.

Patent claim No. 1 has for an object an incandescent lamp which in the main consists of a carbon fibre of high resistance. The spiral, arch or loop shaped arrangement of the carbon permits the lamp to be neat and compact notwithstanding the considerable length of the conductor. The mode of producing the carbon fibre is set forth in the specification to the effect that before carbonization the material is given that thin form and that spiral shape which it is to retain after 1010
carbonization, and afterward carbonization is effected.

To achieve this result two distinct and separate methods are described, viz.: the one the carbonization of a cotton thread or of some other thin wire of fibrous material; and the other the carbonization of thinly and evenly rolled dough of lampblack and tar coiled in the desired form.

Finally, claim No. 1 relates to the connection of the carbon conductor to the conducting wires outside by means of thin platina wires fused into the glass. These 1011
platina wires, however, as stated before, are not an independent element of the invention.

If plaintiff then, in its contingent motion, desires to see claim No. 1 restricted to the employment of carbon conductors made of lampblack and tar, there is the objection, that not every carbon conductor made of lampblack and tar is covered by claim No. 1, but only one thinly rolled out and brought into the desired form before carbonization. The far more significant employment of vegetable fibre, for which a dough made of 1012
lampblack and tar is only a substitute, has been entirely ignored in the contingent motion.

As regards patent claim No. 2, plaintiff has not been able to dispute the novelty of the spiral shape of the carbon filament, the inner portion of the surface of which does not radiate light. A possibly insufficient specification of the claim is not a reason for nullification. Moreover, the patent contains a sufficient specification.

Patent claim No. 3 embraces the method of first

1013 attaching the material to the Platina wires, and then carbonizing it in a closed vessel. This succession of operations embodies the essential idea of the invention. It makes possible the further manipulation of such thin carbon and also brings about the result of driving the oxygen out of the pores of the carbon, as it would act destructively in the vacuum.

Regarding, finally, the English specifications referred to by plaintiff, defendant denies the identity of the same with the contents of the contested German patent.

1014 The English patent No. 10,919 of 1845, generally covers an electric incandescent lamp in which a thin carbon rod cut out of gas retort carbon, is placed in a Torricellian Vacuum.

The introduction of the current is effected in such a way, that one end of the carbon-rod is connected by means of a binding screw to a platina wire, which latter passes through and is fused into the side of the glass; the other end is connected to a copper wire, the lower end of which dips into the mercury of the barometer
1015 tube, mercury and platina wire being connected to the poles of the source of current.

The difference between this construction and that of Edison lies in the facts, that in the latter in place of a rod cut out of gas carbon a specially prepared carbon fibre is used; instead of a Torricellian Vacuum, one prepared in a different manner is employed; instead of enclosing the vacuum in the glass vessel by means of mercury a complete glass globe is used; and instead of the binding screws a substance is employed which unites
1016 the carbon fibre with the conducting wires. Besides this, the manner of subdividing the light is entirely different, inasmuch as King connects several lamps in series in one circuit while Edison employs the multiple arc method of connecting.

Nor is the English Patent No. 119, of 1853, to be regarded as worthy of consideration. It describes electrodes intended for the production of the voltaic arc, and especially a form of electrode made of a metallic core coated with a covering of carbon, carbonized pitch, tar or lampblack. Edison's patent, however, neither

uses the voltaic arc, nor does it employ a metallic con- 1017
ductor coated with carbon. Where in the Edison Patent No. 12,174 a method is described for the carbonization of a spiral-shaped conductor by the aid of a copper wire spiral it is expressly stated that the latter is to be removed before the completion of the lamp. The copper wire therefore takes the place of a tool and is not under patent protection.

The English Patent No. 4626, of Nov. 14th, 1878—the provisional specification—contains, as in the King
patent, the description of an electric incandescent lamp 1018
and certain apparatus for the distribution, regulation and measurement of the electric currents used, and the inventor, Lane-Fox, employs as a light-giving body a leaf of platina or iridium or carbon covered with asbestos or other suitable material, which is fastened between two platina wires and enclosed in a glass vessel, which is exhausted by means of a small glass tube. He then describes in his specification, on the one hand, an incandescent lamp with a metallic, spirally-shaped con-
ductor, and on the other hand, one with a carbon con- 1019
ductor. The former, the metal conductor incandescent lamp, bears no relation whatever to the Edison patent. The latter, the carbon incandescent lamp as described by Lane-Fox, is likewise not identical with the German Patent No. 12,174, for it employs a piece of carbon in a glass vessel which is closed hermetically in such a way that it can readily be opened and closed. With such a mode of closing the incandescent carbon conductor can only have a life of a few hours.

This carbon incandescent lamp is therefore not prac- 1020
tically useful, and hence has neither been incorporated in the final Patent Specification No. 4626, of May 14th, 1879, nor in a corresponding patent claim; a comparison of this lamp with the Edison carbon incandescent lamp is therefore out of the question.

In conclusion, the English Patent No. 1122, of 1879, describes a method of making incandescent lamp conductors out of a mixture of powdered conducting and non-conducting materials and a fusible cement. The surface of such conductors should be coated

1021 with a smooth layer of carbon by means of decomposed carburetted hydrogen and this conductor is to be hermetically enclosed in a glass vessel, into which the conducting wires are introduced, likewise hermetically sealed into the glass. Thereupon every trace of oxygen, carbonic acid or other gas that may attack the material is to be exhausted. For effecting the hermetical sealing of the glass vessel and the hermetical introduction of the conducting wires no other than the long known methods are indicated. There can there-
1022 fore be so much less identity with the German Patent No. 12,174, inasmuch as the latter employs a differently constructed conductor and different means of fastening the same, and prepares the carbon-surface by other means than the decomposition of carburetted hydrogen.

Furthermore, Claim No. 2 of the contested patent is not covered by the English patent No. 4626 of 1878, because, as has been pointed out before, the latter has exclusive reference to metallic conductors covered with non-metallic substances, or to straight carbon pencils.

1023 Other conclusions drawn by plaintiff from patent No. 4626 will not hold good, as the same makes a sharply defined distinction between metal wires with non-conducting surface and carbon bodies, and only says of the former that they are wound into spirals.

In the verbal hearing both parties have in connection with their statements set forth in the complaint and the reply thereto, discussed the contents and meaning of the separate claims of the contested patent.

To begin with, plaintiff asserts—in contradiction of
1024 the defendant—that in claim No. 1 the use of platina wires for the production of the luminous carbon fibre is covered, and besides those previously mentioned, quotes a number of publications to demonstrate the want of novelty of all the styles and methods of production of carbon fibres, as described in Patent No. 12,174. Plaintiff refers in this connection to the periodical, "The Chemical News," vol. 39, page 168; to the English patents No. 14,198 of 1852 and No. 3470 of 1878, and to the "Scientific American," of 1878, vol. 40, page 145, where electric lamps are described in

which the light giving body consists of variously pro- 1025
duced carbon fibers. In all these electric lamps, plaintiff asserts, the aim of the inventors naturally has been to give the carbon the highest possible resistance, as for instance Lane-Fox speaks in his patent No. 4226 of 1878 of a resistance of 300 ohms. Likewise, the multiple arc method of connection upon which defendant lays especial value, has already been used with the Sawyer-Man lamp and has been described in the "Scientific American" as above mentioned.

Regarding Claim No. 2, plaintiff further makes reference 1026
to the English Specification No. 4388, of 1878, of Choate, by which spirally-shaped conductors for incandescent lamps were made known, and remarks that in the patent of Lane-Fox, No. 4626, the partial radiation of light by the carbon spiral was provided. Regarding Claim No. 3 nothing actually new has been advanced by the plaintiff.

Defendant contests the correctness of plaintiff's statements, and asserts that in the publications referred to, as far as they treat of incandescent lamps at all (in 1027
contra-distinction from arc lamps), they always speak of a carbon rod ([English text quoted], rod, pencil of carbon), or of a piece of carbon ([English text quoted], thin piece of carbon), as the incandescing body, while the chief characteristic of the Edison lamp consists in the employment of a spiral-shaped carbon fibre or of a carbon thread as a source of light.

In opposition to this plaintiff disputes that the thread form of the carbon is covered by Claim No. 1, but the term "carbon fibre" is only to indicate the vegetable 1028
origin of the carbon. Moreover, the thread form is already found in the lamps of Lane-Fox and Swan, which plaintiff asserts and attempts to prove by exhibiting two specimens of incandescent lamps, have been publicly in use within the State prior to the application for the contested patent.

Defendant denies the correctness of this assertion, as well as that the lamps submitted were made prior to November 27, 1879.

1029 In conclusion, plaintiff defines its contingent motion
as formulating the patent claim as follows:
"In an electric lamp, that gives light by incandes-
"cence, the employment of spiral-shaped carbon con-
"ductors, which radiate light only from a part of their
"surface, consisting of a mixture of lampblack and
"tar, and which are connected with the same material
"to platina contact wires during their carbonization."
It therefore remained for the Court to deny the prin-
cipal as well as the contingent motion of plaintiff, which
1030 has been done.

The contested Patent No. 12,174 protects a certain
kind of electrical incandescent lamps, the chief pecu-
liarity of which consists in the employment of a carbon
fibre of high resistance for the purpose of giving light.
Regarding the method of production of the carbon
fibre, reference is made in Claim No. 1 to the patent
specification.

In this is prescribed the carbonization of a cotton
thread or the production of any other thin carbon wire
1031 made from fibrous material, or the carbonization of a
dough of lampblack and tar rolled out to a thin wire, and
in such a way that the material to be employed is to be
given the spiral or other desired shape which it is to
retain after carbonization, and that thereupon carboni-
zation is effected. From this two conclusions are
drawn, viz., on the one hand, that by the term "carbon-
fibre" used in the patent not simply any carbon of
vegetable origin is meant, but only the CARBON FILA-
MENT made and shaped in this peculiar way,—on the
1032 other hand, that platina wires as incandescent bodies
are not provided and protected by the patent as plain-
tiff erroneously asserts. Whenever in the specification
platina wires are spoken of they are only intended to
connect the carbon filament with the conducting wires
on the outside of the glass globe. The peculiar char-
acter of this connection is covered by the final words
of claim No. 1, but not the use of platina as an incan-
descing body.

In none of the public prints referred to by plaintiff
is a description of an incandescent lamp to be found

which possesses the characteristic peculiarities of the 1033
Edison lamp as they are above set forth, especially the
use of suitably made carbon thread for giving light by
incandescence. The circumstance, that certain elements
in the Edison lamp, not patented themselves, as for in-
stance, the use of vegetable carbon as the incandescing
body, the spiral form of the same, etc., were known be-
fore the application for the patent, cannot bring into
question the total construction of the lamp as protected
by claim No. 1.

Of the different applications referred to by plaintiff, 1034
first of all those treating of arc lamps should be left un-
considered. For on account of the fundamental dif-
ference in construction and operation which exists be-
tween arc and incandescent lamps, even if the previous
use of similar component parts could be proved—which
is not the case—this would not be a bar to the patenta-
bility of incandescent lamps with corresponding de-
vices. This disposes, therefore, of patents No. 119 of
1853 (Christopher Binks) and No. 3470 of 1878.

Among previously known incandescent lamps, King's 1035
Patent No. 10,919 of 1845 employs as an incandescing
body a platina strip; Lane-Fox a platina or iridium
spiral (Patent No. 4626 of 1878) and also a mixture of
conducting and non-conducting material (Patent No.
1122 of 1879). These patents, therefore, bear no re-
lation whatever to the German Patent which employs a
carbon filament.

The lamps of Sawyer-Man (See Scientific American,
Vol. 40, page 145) and of Roberts (English specifica-
tion No. 14,198 of 1852) likewise the Harrison arc lamp 1036
(English Patent No. 3470 of 1878) all employed vege-
table carbon as the incandescing body, not
in the peculiarly made filamental form which
is the chief characteristic of the Edison lamp,
but in rods, pencils, pieces, ([English text quoted]
pencil, rod thin piece, etc.,) of carbon. The lamp
submitted at the hearing likewise shows a comparatively
thin carbon rod. None of these lamp systems can
therefore be regarded as identical with the Edison pat-
ent; it is therefore superfluous to take testimony as to

1037 the disputed point whether the lamp submitted was in public use within the State prior to the application for the contested patent, about which point moreover no detailed actual statement has been made.

As regards claim No. 2 the plaintiff makes an erroneous interpretation of the law when he assumes a possibly insufficient description to be made a legal reason for annulling a patent. Moreover the maintenance of claim No. 2 is justified by the fact above set forth, that the carbon fibre or rather the carbon filament, in spite of
1038 all the publications cited by the plaintiff, must be regarded as novel. If Choate in his Patent No. 4388 of 1878, has already prescribed the spiral form for the incandescing body, it is irrelevant, inasmuch as by the method of Choate the incandescing body is made from metallic or semi-metallic substances and not in the manner indicated by Edison.

Against the novelty of claim No. 3 only the Binks Patent No. 119 of 1853 has been cited, which, as it relates to arc lamps, must be left out of consideration.
1039 Furthermore, the purpose of the coating of a metallic conductor as described by Choate is essentially different from claim No. 3 of Patent No. 12,174, for with Choate the coating is not intended to establish a connection between the incandescing body and the outside conducting wires, but rather to increase the resistance of the metallic conductor, which serves as an electrode. If, therefore, the entire patent ought to be recognized there is no reason to grant the contingent motion.

1040 The denial of the complaint entails, according to paragraph 20 of the patent law, the sentencing of the complainant to the costs of the proceeding.

Decision IMPERIAL PATENT OFFICE,

E. 356, adh I. (Signed) STÜVE.

PH. SEUBEL,
Translator.

The German words "Faser" and "Faden" are here rendered "fibre" and "filament." All fibres may be spoken of as filaments or threads, but it is not always proper to call a filament (as of tar-putty) a fibre. It is only to this extent that the two German words are not synonymous, as applied to incandescing lamp conductors.—Translator.

IMPERIAL PATENT OFFICE. 1041

BERLIN, April 5th, 1884.

In the civil suit in your Court of Engineer Thomas Alva Edison against the firm of Naglo Bros., symbol of document O. 233. 83 C. K. II. we hereby return documents enclosed in your favor of Feb. 25th a. c. accompanied by an incandescent electric lamp, and answer your question, " whether the above mentioned incandescent electric lamp contains all the essential parts and devices patented to plaintiff by patent No. 12,174, on improvements in electric lamps and *therefore** 1042
comes under this patent," as follows:

The essential points of patent No. 12,174 are according to the three patent claims, as follows:

The first claim covers a lamp, which, according to the exact text of the claim consists in the main of a carbon fibre of high resistance made as described and connected to the metallic wires. The claim contains therefore two essential points:

1. The described production of carbon fibre of high resistance; and 1043

2. The described connection of the latter to the metallic wires.

By the term "fibre" is to be understood a filament-like structure as set forth in a decision as yet unconfirmed of January 24th, 1884, by Part VII. of the Patent Office, in the case for annulling part of the Edison patent; Swan Electric Light Co. of London against the Edison Electric Light Co. of Europe, Limited.

The mode of production therein described involves a natural cotton thread or a thread of fibrous material, into 1044
which is rubbed a dough made of lampblack and tar, or a thread made of lampblack and tar alone, brought into the desired shape and then carbonized. Then follows the fusing of the platina wires into the glass vessel of the

* NOTE.—The italics are my own and call attention to the fact that in the judgment special reference is made to the word "therefore," and the whole opinion set aside on account of it.—Translator.

1045 lamp. The described mode of connecting the cotton thread with the metallic wires undoubtedly relates to the connection of the fibre to the platina wires, and this is done in such a manner that the ends of the fibre are each connected to one end of a platina wire by enclosing them in a dough of lampblack and tar. By the succeeding process of carbonization the carbon is tightly pressed against the platina wire, and by this means a conducting connection is produced.

The importance of this second idea is also set forth
1046 by the fact that a separate claim, claim No. 3, is devoted to this point.

The connection of the carbon fibre to the metallic wires cannot relate to the connection of the carbon conductor with the outside conducting wires by means of the interpolated platina wires, as it has long been known prior to the application for patent No. 12,174, that to conduct current into a vacuum vessel, platina wires must be used.

The remaining claim No. 2 covers a spiral-shaped
1047 carbon conductor coiled in such a way that only a part of the surface radiates light to the outside.

The model lamp sent, if made, as alleged and conceded, after Swan's Patent No. 13,071, coincides with the Patent No. 12,174 so far, as it contains a filament-like carbon conductor, which, however, is not obtained from a natural cotton thread by means of carbonization but out of a parchmentized cotton thread which is intentionally deprived of the fibrous vegetable structure by means of sulphuric acid. A further coincidence
1048 consists in the feature that the thread is brought into the desired form before the carbonization, the ends connected to the platina wires and afterward carbonized.

On the other hand, the Swan lamp submitted does not contain the following essential parts of Patent No. 12,174:

1. The peculiar connection of the carbon conductor with the platina wires.

2. The arrangement of the carbon conductor in such

a spiral that only a part of the same radiates light to 1049
the outside.

Disregarding the employment of enlarged ends of the carbon conductor which is not made use of in the model presented, the connection of the carbon conductor to the platina wire is effected according to Swan's direction in Patent No. 13,071 in such a manner that the ends of the carbon conductor and the platina wire are wrapped together with cotton thread or blotting paper which latter is then pressed together by the parch-
mentizing process; this method is essentially differ- 1050
ent from the above mentioned as described in Patent No. 12,174.

The coiling of the carbon conductor in the presented model is such that light is radiated from all parts of the surface, while in Claim No. 2 of the patent No. 12,174 it is set forth as essential for the manner of coiling, that only a part of the surface radiates light to the outside.

On the strength of the enumerated departures of the
Swan lamp from the patent No. 12,174 the above- 1051
mentioned question must be answered with "*No.*"

In conclusion, we beg to add our humble request that we be notified in due time of the final result of this law suit by sending a copy of the decision of the Court with reasons.

IMPERIAL PATENT OFFICE, Part II.
(Signed) MEYER.

To the Royal General Court of Justice, Second Civil Chamber, in Berlin.

E. 356, II. 1052

PH. SEUBEL,
Translator.

1053 ## IMPERIAL PATENT OFFICE.

In the case of Engineer Thomas Alva Edison, of Menlo Park,

against

The firm Naglo Bros. & Co., of this City.—O., 233, 1883. II., C. K.

BERLIN, S. W., Dec. 30, 1884.

We beg to hand you, in compliance with your favor
1054 of June 13 of this year, the desired opinion, with documents enclosed.

The two questions asked are as follows:

If the *more essential* part, or at least *an essential* part, of the invention secured to plaintiff by Patent No. 12,174 does not consist of the *idea* that for the production of electric light a thread-shaped carbon conductor is used, no matter out of what material or by what mode of treatment made, and which is put in the desired shape before carbonization, connected to the ends of
1055 the platina wires and is *then carbonized;* and

If *without employment* of this idea the Swan lamp could not be produced.

The first one of these two questions is to be answered in the affirmative, inasmuch as an *essential* part of the invention secured to plaintiff depends upon the fact that a thread-shaped body is brought into the desired shape before carbonization, connected with the ends of the platina wires, and is then carbonized.

Claim No. 3 primarily says unmistakably that it is to
1056 be regarded as an essential part of the invention that at first the ends of the carbon thread are connected to the platina wires and that only then the whole, including the carbon thread, is submitted to the carbonizing process.

As regards the question whether the shaping of the whole filament preceding carbonization is also an essential part of the patent, it is to be said that in the specification the different operations are recited in this order only.

Likewise, in the action on the part of the Swan

United Electric Light Company, Limited, against the 1057
holders of this patent, the attorneys of the latter in the verbal hearing have especially stated that the material is to be given such a thin form and such a spiral shape as it should retain after carbonization, and only afterward carbonization is performed (see attached Copy of the Decision of the Patent Office, Part VIII., p. 10). Part VII. of the Patent Office concurs in this view, and in the reasons for the decision it is said that the term "Carbon fibre" * (a. a. O. S. 22) does not mean simply
any kind of carbon of vegetable origin, but only the 1058
carbon filament produced and formed in this peculiar way, and immediately preceding this (a. a. O. S. 21) it is said about this peculiar method of production, with reference to the specification, that the material to be employed, which should consist of cotton fibre or a thin wire of fibrous material, or out of a dough made of lampblack and tar, rolled out into a thin wire, is to be given the spiral or other desired shape which it should retain after carbonization, and that *only then* carbonization takes place. 1059

The second question, if without this peculiar mode of production the Swan lamp could not be made, must be answered in the negative.

For the production of incandescent light it is not absolutely necessary that the carbon thread should be brought into the desired shape before carbonization.

An experiment made in the presence of one of our members has shown that a carbon thread which has gone through the entire process of carbonization can
subsequently be bent at pleasure, retain the shape 1060
given, and be connected to the platina wires after carbonization.

IMPERIAL PATENT OFFICE, PART II.,
(Signed) MEYER.

PH. SEUBEL,
Translator.

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* "Carbon fibre" is synonymous with carbon filament.—P. Seubel, Translator.

1061 **Decision of the Royal General Court of Justice of Berlin.**

[Note by translator: The term "fibre," as here used, is *synonymous with "filament."*]

Confidential.
Printed as manuscript.
0. 233. C. K. II.
1835.
1062 Announced March 9th, 1885.
Signed, Wille, Clerk of Court.

IN THE NAME OF THE KING:

In the case of
Thomas Alva Edison, Engineer, of Menlo Park, New Jersey, U. S. A., Plaintiff, represented by Attorney Dr. Alexander Katz,

Against

1063 the firm Naglo Bros. and the owners thereof:

1. Emil Naglo, manufacturer,
2. Wilhelm Naglo, manufacturer, of Berlin,

Defendants, represented by Councillor of Justice Makower.

The Second Civil Chamber of the Royal General Court of Justice composed of the following Judges:

1. Director of General Court of Justice, Piehatzek;
1064 2. Councillor of General Court of Justice, Danenberg;
3. Councillor of General Court of Justice, Messow;

decides according to law:

1. The defendants are sentenced to discontinue the employment of incandescent electric lamps placed in use prior to the serving of the complaint, and made according to the German Patent No. 13,071, granted to Joseph Wilson Swan, and to abstain in the future from

using, bringing into trade and offering for sale such incandescent lamps. 1065

2. The rest of the complaint is dismissed.
3. The costs of the proceedings in court are to be borne in equal parts by each party. The costs of each party out of court are to offset each other.
4. Sentence 1 can be suspended temporarily if plaintiff makes a deposit of 50,000 marks as security.

STATUS.

1066

To Thomas Alva Edison, of Menlo Park, upon application received November 26th, 1879, has been granted the German Patent No. 12,174 for improvements in electric lamps, taking effect from the day following, as per copy of the patent contained in the documents pages 11 to 13.

The patent claims are as follows:

1. An electric lamp which gives light by incandescence, and in the main consists of a filament of carbon of high resistance, which is made as described and 1067 secured to metallic wires.
2. A filament or strip of carbon fibres, wound in spiral shape in such a way that only part of the surface of the carbon conductor radiates light.
3. The method herein described of securing the platina contact wires to the carbon filament, and carbonizing the whole in a closed chamber, as set forth.

Defendants use and introduce into the trade electric incandescent lamps, the essential features of which consist of an incandescent carbon wire enclosed in a 1068 hermetically sealed glass vessel, wholly or partially exhausted, which carbon wire is made from a cotton thread, parchmentized before carbonization by the action of sulphuric acid, and connected with thin platina wires fused into the glass.

The German Edison Company, provided as alleged, with a power of attorney from plaintiff, requested defendants to stop the further introduction of the electric lamps brought into public use by them, as by the

1069 introduction of these lamps plaintiff's patent, No. 12,174, was infringed.

As the defendants did not comply with this request, plaintiff has made complaint with the motion :

To sentence defendants with costs

(a) To discontinue the employment of the incandescent electric lamps brought into use prior to the serving of the complaint.

(b) To stop the introduction and the offering for sale of such incandescent lamps.

1070 (c) To desist from the use, the sale and the offering for sale of such incandescent lamps as they used, sold and offered for sale before the serving of the complaint, under the penalty of a fiscal fine of 1000 marks for every case.

(d) To pay for the injury done to plaintiff by the continued use, sale and offering for sale, since the serving of complaint.

(e) To decree that sentence can be executed provisionally, security being given.

1071 Plaintiff defines the substance of his invention, protected by patent No. 12,174, as the construction of an electric vacuum lamp, in which is used a somewhat thin carbon conductor, the resistance of which to the electric current is greater than the resistance known heretofore in electric lamps, which conductor therefore allows the subdivision of the electric current, and the insertion of any number of lamps in a circuit. And, further, in the use of a carbon conductor which is bent in such a manner that it is
1072 enabled to expand when heated, and to contract when cooled, without cracking or breaking.

Plaintiff explains that to achieve this result the carbon conductor must be made in such a manner that the material to be carbonized must be given that thin and bent shape which it shall have and retain after carbonization. To prevent the breaking of the fine carbon in the further manipulation, it is not fastened to the platina contact wires in its carbonized state, but the material is to be fastened to the platina wires already fused into pieces of glass and afterward it is subjected

to carbonization. To satisfy all these requirements and 1073
to obtain a carbon of uniform thickness, two independent means have been invented by him :

a) The use of a cotton thread or other fibrous material (linen thread, wood splints, paper), to which is given a shape which freely permits expansion, for instance the shape of a loop or spiral, and in this shape is then carbonized.

b) The use of a dough of lampblack and tar which is rolled out as finely and uniformly as a wire of vegetable fibre and to which is then given the desired shape 1074
before carbonization.

Claim 1 protects the construction as a whole of an electric lamp which gives light by the incandescence of a carbon filament made as described, which filament is placed in an exhausted glass vessel and is connected with the outside conducting wires by thin platina wires fused into the glass.

The use of these platina wires is not an independently patented element of the lamp but a necessary integral part of the invention as a whole, and only through 1075
the use of the fine carbon conductors invented by him has it been made possible to use such thin platina wires as are fused into the glass of the lamps in question, these wires offering to the current but a low resistance as compared with that of the incandescing body and for this reason neither heating themselves nor the vacuum globe to any extent.

Claim No. 2 protects a coiled carbon fibre of which only a part of the surface radiates light.

The use of a spiral recommends itself because it per- 1076
mits a greater length of the incandescing body to be placed in a small glass vessel and while only a small part of the surface radiates light to the outside, adjacent parts of the spiral exert a heating effect upon each other whereby the specific heat of the whole wire may be raised to such an extent that the sudden raising or lowering of the light caused in straight wires by the least fluctuation of the electric current, may be obviated. Moreover the spiral shape is not claimed to be an absolutely essential requirement of the Edison lamp

1077 as is shown by the patent specification which speaks of this form only hypothetically.

Claim 3 protects the method of fastening the platina wires to the carbon filament by means of a plastic and carbonizable material and of carbonizing the whole afterwards.

Plaintiff asserts that the first two claims of his patent are infringed by the introduction of the Swan lamps; viz.: Claim 1 is infringed, because in the Swan lamp an incandescing carbon wire radiating light is
1078 made according to Edison's direction by first winding a cotton thread into a spiral, then exposing to heat and carbonizing, and finally placing in a vacuum glass globe and connected with the outside conducting wires by means of fine platina wires as practiced by Edison. Claim 2 is infringed, because on the one hand only a part of the carbon conductor is brought to incandescence in consequence of the spiral winding, and because, on the other hand, the carbon wire is thickened at the ends where it is connected with the platina wires
1079 and therefore offers at these ends a smaller resistance to the electric current than in the other thinner part, and for this reason: The carbon wire does not become incandescent at all or becomes only slightly red at these points precisely as described in plaintiff's patent for the purpose of maintaining a good connection between carbon conductor and platina wire.

Concerning Claim No. 3 plaintiff leaves it an open question whether the employment of Edison's idea as practiced in the manufacture of the Swan lamp can be
1080 prosecuted in Germany, as this claim relates to a method, and the manufacture of the Swan lamp, and consequently the employment of Edison's method is going on in England.

Defendants have denied the use and infringement of plaintiff's Patent No. 12,174 and make a motion for the setting aside of the complaint on the following grounds:

The electric lamps manufactured according to the Edison Patent No. 12,174 are not commercial; the lamps sold by defendants are manufactured according

to a German Patent No. 13,071, granted to Joseph Wilson Swan for "Improvements in the manufacture of carbon loops for electric lamps." The claims of this patent are as follows: 1081

1. The production of carbon for electric lamps from cotton thread, which, before carbonization, has been subjected to the action of sulphuric acid in such a manner that the vegetable fibre assumes that condition of partial solubility and interior intermixture which takes place at the parchmentizing of blotting paper.

2. The production of carbons with thickened ends 1082
by bringing the materials used for the carbon, yarn or paper, in intimate contact with the materials used for the thickening of the ends by means of the parchmentizing process.

3. The intimate connection of the conductors of platina or other suitable metals with the thickened ends of the yarn or similar material.

This patent, self-contained and independent from plaintiff's patent, can unquestionably be used by Swan, and even if wrongly granted (which is not the case) he 1083
could construct lamps after this system and put them on the market till his patent is declared invalid. But outside of this the Edison patent in claim 1 only protects a carbon fibre "made as described;" the Swan lamps do not contain such a fibre but a fibre obtained in a specified manner by parchmentizing the cotton thread.

The words of claim 1 "and connected with metallic wires" have been falsely interpreted by plaintiff. They do not relate to the practice known long before Edison 1084
of fusing platina wires into glass for the purpose of connecting the incandescing body and the outer connecting wires, but to the method of fastening the carbon filament to the platina wires by means of a cement of lampblack and tar, which method is specially protected by claim 3. But this process is not used in the Swan lamps, as this connection is neither made in the manner proposed by Edison nor according to the method patented to Swan but according to Gimingham's patent No. 19,851.

1085 Nor has the second claim of plaintiff's patent been infringed upon, as in the Swan lamps the whole carbon conductor radiates light, not simply a part of it. Moreover, Edison's method of using a carbon fibre for the production of the electric incandescent light is not novel, but as is shown in the English patents No. 10,919 of 1845, No. 119 of 1853, and No. 4,626 of 1878, have been known for a long time.

Finally defendants allege that plaintiff separates his three claims. They would not have been patentable
1086 each for itself, as separately they would not allow of a practical application. There were not three patents granted but one patent only.

To these arguments plaintiff replies that Swan's proposed treatment of the cotton thread was a minor manipulation without any importance and was only set forth by Swan to give to his method of manufacture the appearance of a modification. The use of these worthless methods which do not detract from the distinctive features of the Edison lamp nor add anything original,
1087 could neither justify Swan in manufacturing lamps in accordance with such processes and which in other respects possess the essentials of the Edison lamp, nor give the defendants the right to use, offer for sale and introduce in Germany such lamps made abroad.

The copartner of the defendant firm, Emil Naglo, has been requested to certify under oath that the incandescent lamp exhibited to the Court by the attorney of the defendants, is exactly identical with those brought into the market by the defendants, which oath he made in
1088 due form in the proceedings of January 9th, 1884.

The Imperial Patent Office, having been provided with a specimen of the lamps used by defendants and unquestionably constructed in accordance with the Patent No. 13,071 of Joseph Wilson Swan, has rendered opinions contained in the documents page 70 *et al.* and page 158 *et al.* concerning the questions formulated in the proceedings of February 22 and June 13, 1884. The contents of these opinions has been read to the court.

In contradiction to the view expressed in the opin-

ion rendered April 5th, 1884 (page 70 *et al.*) that the 1089
connection of the carbon fibre to the metallic wires mentioned in claim No. 1 of the Edison patent No. 12,174 did not relate to the connection of the carbon conductor to the metallic conducting wires by means of interposed platina wires, but that it relates to the connection of the fibre with the platina wires by means of moulding them together with a dough made of lampblack and tar to be carbonized, the plaintiff further states that in the yet unconfirmed decision rendered by
Part VII of the Patent office in the case of the Swan 1090
Electric Light Co. of London, Limited, plaintiff, against The Edison Electric Light Co. of Europe, Limited, of New York, defendant, also the Swan Co. itself in its appeal against this decision to the Supreme Court, advanced the only correct interpretation in accord with the meaning and wording of the Edison Patent, that by claim No. 1 the connection of the carbon conductor with the outside conducting wires by means of interposed platina wires, is protected.

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REASONS.

Concerning the claim advanced by the defendants that, so long as the Swan patent No. 13,071 is in force, lamps manufactured according to this system can be put on the market, it is to be remarked that letters patent being an absolute decree to prohibit, originally gives to the owner simply the right to interdict the use of the patented invention without his permission, so that
in the present case the owner of the patent No. 13,071 1092
would have the right to interdict the use of his parchmentizing process in the manufacture of carbon incandescing bodies from cotton thread.

According to paragraph 4111 of the patent law, he has also the right to carry out his invention commercially. In doing so older rights of other patent owners must not be infringed upon.

If therefore an older right to prohibit stands in the way of the exploitation of an invention, the later inventor may prohibit others from using his invention

1093 but he is actually restrained from the industrial exploit-
ation of his invention so long as the older right to pro-
hibit remains in force.

The patent No. 13,071 has been granted to the legal
predecessor of defendants, Swan, not "for electric
lamps" but for "Improvements in the manufacture of
carbon loops for electric lamps," that is for a certain im-
proved process in the manufacture of carbons for electric
illuminating purposes. If, therefore, this invention can
only be put into practice if the previously patented im-
1094 provements of Edison are used with it, Swan's patent
is practically subsidiary to Edison's older patent—that
is to say, Swan cannot put his own improvements in
practical use in Germany without Edison's permission
to use his patent. Third parties* can obtain inde-
pendent patents only for improvements on already pat-
ented devices, and the Patent Office in granting them
has only to examine whether these improvements really
have a practical value, and not whether they are legally
dependent upon a permission to be obtained by the ap-
1095 plicant to use the patents of others.

In case of collision of two patents the Civil Judge has
to decide.

In the present lawsuit it remains, therefore, to be de-
termined whether the exploitation of Patent No. 13,071
by the manufacture of incandescent electric lamps
brought into the market by the defendants, involves an
infringement of the plaintiff's Patent No. 12,174.

The infringement of a patent by manufacturing imi-
tations does not necessarily call for a complete copy of
1096 the patented invention, but it suffices if the latter is re-
produced in some essential parts, or if the imitation
coincides only in certain essential protected points with
the object of the patented invention.

* "Third parties" can obtain independent patents in Germany *only* on improvements of already patented devices, while the owner of a patent may take out any number of supplementary patents on the same invention. *others* have to take *independent* patents, and then try to make them stand on their own bottom as best they can. —Translator.

If, therefore, defendants emphasize their statement 1097
that plaintiff separates his three claims while they
would not have been patentable each for itself, in order
to prove that the use of one of the devices described in
plaintiff's claim does not constitute an infringement of
Edison's patent, this objection is set aside by the con-
sideration that, if different improvements are made the
the object of the patent, the several separate claims
contain the different inventions, all relating to the pat-
ented construction as a whole, but embodying separate
ideas of invention, and enjoy, therefore, independent 1098
patent protection, each for itself. Moreover, the point
at issue is the "invention" rather than the claims, as
the law does not recognize "patent claims," and only
"inventions" are patented, all the essential elements
of which are protected by the patent.

The Court has gained the conviction that by the
manufacture of the Swan lamps, claim No. 1 of the
plaintiff's patent is being infringed, inasmuch as the
same covers, as an essential part of the patented inven-
tion as a whole, the production of an incandescing body 1099
of filamentary form for electric lamps by carbonization
of cotton thread or other fibrous material (linen thread,
wood splints, paper) or of a dough made from tar and
lampblack (eventually graphite, carbon).

The two opinions of the Imperial Patent Office of April 5th and December 30th, 1884, declare this incandescing body to be an essential element of plaintiff's patent.

The idea of invention protected therein consists in
the construction of an incandescing body of filamentary 1100
form, of carbon manufactured by carbonizing cotton
fibre to which can be given the coiled shape by bend-
ing; consequently in the method of creating an incan-
descing body by working the otherwise brittle carbon
into loops, spirals, &c., which body in its tenacity
approaches the metals, but at the same time can resist
the action of much higher temperatures and possesses
such an electric resistance as to allow the division of
the electric current. The assertions of defendants, that

1101 this alleged invention of Edison is not novel and that the lamps manufactured in accordance with patent 12,174 are not practically useful, are irrelevant in the present suit but belong to the pending action seeking an annulment of plaintiff's patent.

The Court had only to examine whether the above stated idea of invention is secured to plaintiff by the patent No. 12,174 issued according to law.

The lamps put on the market by defendants undoubtedly contain an incandescing body made by carbonizing
1102 *a cotton thread to which by bending the desired shape has been given.*

Therein an infringement of plaintiff's patent must be found. The method employed by Swan to parchmentize the cotton thread before carbonization may contain an improvement of Edison's process, but it does not justify the use of the latter without Edison's permission. The practical success of Swan's operation consists, according to the opinion of the Patent Office of April 5, 1884, in the fact that the texture of vegetable
1103 fibre is destroyed in the cotton thread. But this circumstance is not sufficient to establish a material difference between Swan's and Edison's incandescing body.

How little weight the latter attributes to the vegetable fibrous texture of the carbon filament may be estimated when he admits a filament formed of tar and lampblack (where a fibrous texture is out of the question) as a choice side by side with the cotton thread. It is only essential that as an incandescing body a carbon of
1104 the peculiar filamentary form is used.

When the Patent Office in its opinion of December 30th answered the second question propounded by the Court, in the negative, with reference to the fact that special stress was laid in the first question on the point that the filament was to be put into the desired shape before carbonization, because it is feasible to bend the carbon filament even after carbonization, the Court did not see fit to regard this as of deciding importance for the following reason:

The quoted form of propounding the question was 1105
selected only for the purpose of distinguishing between an Edison carbon filament brought into the desired shape before carbonization and an incandescing carbon filament perhaps cut out of carbon already made—for that it was feasible to make spiral carbon thread in a third way, namely, by bending after carbonization, was not known to the Court—and thus designating Edison's idea of making a flexible thin spiral carbon thread as the most essential part of Patent No. 12,174. The
Patent Office gives its opinion that the flexibility of a 1106
carbon filament thus made is not lost by carbonization and on account of this fact it answers in the negative the question put by the Court while in ignorance of this fact. But the substance of the present invention of Edison is based on the fact that in the first place a thread-like incandescing body of carbon substance is made to which by bending could be given a coiled shape. This is borne out by the opinion of April 5th and also by the affirmative answer to the first question
in the opinion of December 30th. If afterwards the 1107
discovery is made that these carbon filaments can be bent even after carbonization, it cannot be assumed because Edison unnecessarily prescribes that the bending should be done before carbonization, that a lamp provided with such a flexible carbon conductor could be made without the use of Edison's idea. Considering the fact that in claim 1 (among other things) the construction of a coiled filament, obtained by bending, is patented to the plaintiff as novel, it may be regarded
as non-essential that Edison prescribes the bending to 1108
be done before carbonization, but with reference to a subsequently observed fact this may be regarded as immaterial.

Finally the circumstance that the Patent Office in the opinion of April 5th has also answered negatively the question put by the Court, is explained by the wording of the question.

The Patent Office sets forth that not "all the essential parts and processes" of the improvements patented

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Finally the circumstance that the Patent Office in the opinion of April 5th has also answered negatively the question put by the Court, is explained by the wording of the question.

The Patent Office sets forth that not "all the essential parts and processes" of the improvements patented

1109 to plaintiff are contained in the lamps of defendants and arrives at a negative answer to the second part of the question, which by the word "therefore" makes the presence of all essential parts and processes appear as a presumption for the existence of an infringement. In the opinion is further stated (sheet 71 v. of the documents) that a coincidence exists in so far as the Swan lamps contain a thread like carbon conductor obtained by carbonization of a cotton thread which was bent into the desired shape before carbonization.
1110 This point, as mentioned above, has been considered as the essential part.

Inasmuch as the Court, on the basis of the above-mentioned considerations has established the existence of an infringement on claim No. 1, it yet remains, in accordance with the principles cited above, to look into the question whether also the other claims have been infringed in the manufacture of the lamps sold by the defendants.

Therefore, the defendants must be sentenced, as has
1111 been done in accordance with paragraph 4 of the patent law.

The motions of plaintiff, *a*, *b* and *c*, are by this sentence allowed to prevail with exception of imposing a fine which according to paragraph 775, C. P. O. is only admissable in cases of compulsory execution of a sentence where the defendant acts in opposition to the obligations imposed by the sentence.

Motion *d* is denied, because, according to section 34 of the patent law a person is only held to pay damages
1112 if he *knowingly* acts against the rules of sections 4 and 5. Considering the difficulty and uncertainty of the questions involved, it could not be assumed off hand that the owners of the defendant firm from the moment of the serving of the complaint, were conscious that they infringed on plaintiff's patent by the sale of the lamps in question.

The legal fiction set forth in section 222, A. L. R. 17, that the dishonesty of the owner begins at the latest with the serving of the complaint, could according to

the wording of section 34 of the patent law, find no 1113
analogous application in the present case. The decision as to the costs and as to the provisory execution of the sentence follows from sections 88 and 650 of R. C. P. O.

(Signed :)

Piehatzek. Dannenberg. Messow.

Ph. Seubel,
Translator.

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1117 ROYAL COURTS OF JUSTICE,

MAY 20th, 1886.

IN THE HIGH COURT OF JUSTICE.

CHANCERY DIVISION.

Before Mr. Justice BUTT (sitting for Mr. Justice NORTH).

1118 EDISON & SWAN UNITED ELECTRIC LIGHT COMPANY, LIMITED,

vs.

WOODHOUSE & RAWSON.

Judgment.

MR. JUSTICE BUTT: The Plaintiffs in this action
1119 complain of the infringement of three patents relating to the construction of an electric incandescent light. The first of those Patents is that of Mr. Edison which I will describe later on. The principal feature, I as understand the matter of Mr. Swan's Patent, is the process by which he proposed to make and maintain, or proposes to maintain a nearly perfect vacuum in the globe. Mr. Gimingham's Patent is one for fixing the carbon burner of the incandescent lamp to the platinum wires.

The Defence consists of a denial of the validity of the
1120 Patents and a denial of the infringement. As to Messrs. Swan and Gimingham's Patents, I intimated at an earlier stage of the proceedings that there was no evidence of the infringement, and I do not understand that that view has since been seriously contested. The question, therefore, of the validity of those two patents becomes, for present purposes, immaterial. Their validity is beyond the sphere of our present inquiry.

Now, with reference to Mr. Edison's Patent, which is a patent of the 10th May, 1880, there is one fact, which is either admitted or beyond contest in this case,

and that is, that before the date of the Specification in 1121
question, no good and efficient incandescent electric lamp was made or known. The invention Mr. Edison claims has been compendiously stated by Sir Frederick Bramwell in his evidence, and he states it in these words. He is asked by Sir Richard Webster this question: "Of course the construction of the Specification is entirely for my Lord, but would you please tell us, only for the purpose of pointing to previous knowledge, what combination you find described there as an electric
machine or lamp. *Answer*. I find a vessel made entirely 1122
of glass containing a carbon filament attached to conducting wires which wires are sealed through the glass. I find that this vessel is to be exhausted of its air to a very great degree, the Patentee mentioning that the one millionth of an atmosphere may be left. The Patentee says that with a lamp of that construction light can be obtained by rendering the filament incandescent by means of an electric current." That is his account of the invention,
and I adopt that account, and adopt it without the 1123
slightest hesitation, because it is not a matter which depends on my own judgment. It was accepted by all the scientific witnesses called by the Defendants. It was accepted in terms by Dr. Frankland, and the other gentlemen who were called on the same side stated that they agreed with his evidence.

Now, that is the invention for the infringement of which those of the Plaintiffs who are owners of the legal and beneficial interest in this Patent, No. 4576, are now
claiming an injunction and damages. As I have said, 1124
the Defendants deny the validity of the Patent, they also deny its infringement by them. I think it will be convenient to deal with the latter question first. I have all along been clearly of opinion that there is no proof of infringement of Claims Nos. 3 and 4 in Mr. Edison's Patent. Those Claims are as follows: "No. 3. A coiled carbon filament or strip arranged in such a manner that only a portion of the surface of such carbon conductor shall radiate light as set forth. Fourth. The method herein described of securing the platina contact wires

1125 to the carbon filament, and carbonising of the whole in a closed chamber substantially as set forth." I now think, whatever may have struck me at different parts of this inquiry, there is no infringement of Claim No. 1, and I shall be prepared so to hold if necessary. Claim No. 1 is in these words: "An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described and secured to metallic wires as set forth." But in the view I take of Claim No. 2 this question becomes unimportant.

1126 Now, the question of the infringement of Claim No. 2 depends on the meaning to be attached to the words in it—"a carbon filament." If those words mean a carbon filament made as described in the Patent I should hold that there was no proof of its infringement, but I do not so interpret those words. I hold them to mean any carbon filament, however made, which possesses certain qualities or properties mentioned in the Specification, or necessarily resulting from the description there given. To answer that description the carbon filament
1127 must, I think, possess flexibility and resilience. It must be of small cross-section, offering a high degree of resistance to the passage of the electric current, and it must present but a small surface from which radiation of light can take place. I am disposed to think, but on this I refrain from giving a decided opinion, that the degree of resistance must not be less than 100 ohms, as mentioned in page 3 of the Specification. Taking the above to be a correct interpretation of the words "a carbon filament" in Claim 2, it is clear that
1128 there has been an infringement of the Patent by the Defendants. Without reading the evidence of the Plaintiff's witnesses it will suffice to refer to part of that given by Mr. Rawson, one of the Defendants. Now, in the course of his evidence, Mr. Rawson states as follows: "We have used carbon filaments connected at the ends with platinum wires in a vessel made wholly of glass; practically, the leading wires passing into and from the reservoir are sealed into the body of the glass vessel, and the air is exhausted so as to get as good a vacuum as you can. We

use that combination with the object of getting a good 1129
incandescent lamp, and in that incandescent lamp we use a carbon filament that is flexible, and as stable at a high temperature as we can get it. We do not use Edison's processes for the purpose of making the filament. What we do is in substitution for those processes. Our process of making and preparing the carbon filament is superior to Edison's." That is his evidence, and, as I have said, taking that evidence and applying it to the interpretation I have put, rightly or
wrongly, on the words "carbon filament" in Claim 2, 1130
there is an infringement of the Patent. But it is said, even so assuming the infringement, the Defendants still are not liable in this action because the Patent is invalid. I will deal, as well as I am able, with the various arguments by which they maintain such to be the case. It is not always easy to separate in a matter such as this that which Counsel have argued from that which some of their witnesses have said; and it may be, in stating the objections, I shall in one or two in-
stances deal rather with the evidence of some of the 1131
witnesses than with the Solicitor-General's argument. I am anxious, of course, not to put anything into his mouth which he did not express. At the same time there are one or two matters in which I think the witnesses have gone beyond what he has argued. Of course, if he had given up the points expressly, I should not further refer to them.

The first reason, as I gather, in support of the invalidity of this Patent is this: It is said a carbon fila-
ment, when taken to mean that which I have held it to 1132
mean, is a description too vague and indefinite, or, to use the Solicitor-General's own words, too large. That is an argument to which I cannot accede, for I see no reason why a carbon filament having the properties mentioned in Mr. Edison's patent, and which the Patentee tells the public how to make, may not properly be the subject of a patent, although it is capable of being made by methods and of materials other than those set forth in the Specification. This observation certainly does not lose any of its force when the filament

1133 in question is not the thing patented, but only one of the several parts of a combination patented. I am not professing to put the arguments in the order in which they were given. Secondly, it is said that the Specification is not such as would enable a competent workman to make the lamp. The Plaintiffs' witnesses have stated that in their opinion it would enable him to make the lamp. I use the word lamp for the moment apart from the question whether it is a good lamp. Having had an expression
1134 of opinion from several of the Plaintiffs' witnesses to that effect, I find that when Dr. Odling comes to be examined, or cross-examined, I think it is, on the subject, he says what I am going to read: "Mr. Edison first applied the word filament to the conductor of an incandescent lamp. Any competent electrician could make, by the description in Edison's Patent, the carbonised filament there described. Geissler's vacuum tubes were perfectly well known in England. They were wires sealed through the glass. Sealing through
1135 the glass was a perfectly well-known operation to an electrician. A competent electrician would want no other direction as to sealing the wires, than Edison gives in his Specification. A competent electrician would have no difficulty in properly exhausting the globe from Edison's Specification." Now, in the conflict which exists, I take that as making very highly in favour of what the Plaintiffs' witnesses have said, and I hold, therefore, that the evidence does establish (it would be sufficient to displace the converse proposi-
1136 tion) that the Specification in question is one which would enable a competent workman to make the lamp.

But then, in the next place, I understand it is said that a lamp made according to the Specification would not be a good lamp. So say some, certainly, of the Defendants' scientific witnesses; but there is evidence from the Plaintiffs' witnesses to the contrary, and, moreover, the Solicitor-General expressly stated that he did not dispute the utility of Mr. Edison's Specification.

THE SOLICITOR-GENERAL: That it had sufficient utility 1137
to support it.

MR. JUSTICE BUTT: I take that to be so. Under those circumstances, in the conflict, I come to the conclusion that a sufficiently good lamp, for the purpose proposed I should say, may be made by a competent workman, from the description given in Mr. Edison's Specification.

Fourthly, it was said by the Solicitor-General—and at one time I was strongly inclined to go with the suggestion—that the patent was invalid, because at the 1138
time of the Final Specification, Mr. Edison himself knew a better method of making a filament, and in support of that proposition his Provisional Specification of the 15th December, 1879, No. 5127, was referred to. Now, the date of that Provisional Specification, it will be observed, is subsequent to the date of the Provisional Specification which we are now considering, which was of the 10th November preceding, but it was many months prior to the Final Specification we are considering, and, therefore, it is perfectly true to say 1139
that at the time of the Final Specification Mr. Edison knew—I do not know whether I ought to say of a better mode—but knew, at all events, of another mode of manufacturing his carbon filament. The Solicitor-General said a better mode, and perhaps he is warranted in that; I am not prepared to deny it. Therefore, the argument is, he ought to have disclosed it in his Final Specification, because a Patentee is not entitled on the authorities and as a matter of good sense to withhold from the public a discovery of which 1140
he was aware, forming an important integral part of his Patent, and then take out another Patent afterwards for that. It was said that so to do would be to put the public, or those, at all events, who dealt in such matters, to the inconvenience and expense of taking out a license to use two patents, whereas, they ought to have had the whole benefit of the user by taking out a license for the one. It must, however, be borne in mind that Mr. Edison does not claim in his Patent 4576 for the manufacture of the carbon fila-

1141 ment. His Claim is for the union of a carbon filament
possessing certain properties with the other parts of his
combination. There is no evidence that at the time of
filing his Provisional Specification 4576, he had discov-
ered or knew of the process in 5127. I agree with Mr.
Aston that an inventor has no right to put into his
Final Specification, as part of his invention, a discovery
which he had not made at the time, of which he was
ignorant when he filed his Provisional Specification. I
think, therefore, the contention on this head cannot
1142 avail against the Plaintiffs.

But, further, it was alleged that the invention was
not new; and this is the part of the case that has oc-
cupied the greater part of our time. It is perfectly
true that a number of other Specifications anterior to
Mr. Edison's Patent have been adduced, describing
either the separate parts of Edison's combination or
something like them. Without losing sight of the
others, I refer especially to those of Mr. Lane-Fox, Mr.
Pulvermacher, M. Sidot, and Mr. Swan. But no one
1143 of those Specifications, unless it be Swan's, con-
tains the combination described in Mr. Edison's Patent
No. 4576. That I am right upon this is clear from the
evidence generally. I will again read a passage from
Dr. Odling's evidence, which seems to me pertinent on
this matter. He says: "Excepting Swan's, I cannot
point to anything in the anticipations in which any
other than a rod or stick of carbon alone is described."
In the mass of evidence, I have marked I am afraid,
the wrong passage. I think the passage to which I
1144 refer is in another part of his evidence. There is an-
other passage which, I think, referred to Claim No. 1,
in which he deals with the matter.

The Solicitor-General: Can we assist your Lord-
ship?

Mr. Justice Butt: I am afraid I cannot hit on the
passage at present. I must content myself with saying
that there is a passage in Dr. Odling's evidence which
to my mind strongly confirms what I say is a fact on
the whole of the evidence, that, at all events, if we ex-

cept Swan's, none of the other publications contained 1145
a combination of all the elements of Mr. Edison's.

Mr. Aston: I think your Lordship has done this.
You have put down compendiously the result of about
three pages of exhaustive evidence as to the prior Speci-
fications.

Mr. Justice Butt: It was from one of those pages I
was citing the passage I wished to put my hand on. I
do not find it; therefore I will content myself with stat-
ing my impression of the evidence. If I am wrong
upon that of course the Defendants will have any benefit 1146
they may get from my error. That I take to be the
case.

Mr. Aston: I can give your Lordship the reference
now, at page 326, question 2063: "Mr. Justice Butt:
Is this a fair result of your answer; correct it if it is not.
No competent workman would find in any or all of those
Specifications, including Swan's, that which would
enable him to make such a lamp as is specified in Edi-
son's Claim."

Mr. Justice Butt: I think that is the passage. I 1147
have been using mainly my own notes because they
are rather more compendious than the shorthand notes;
but, I am sorry to say, they are not so easy to read.

I have referred to the anticipations put forward by
the Defendants. I do not propose to go through those
publications in detail; but a good example of them, I
think, may be found in the Patent of Mr. Pulvermacher.
It is said that that is a clear anticipation, at all events,
of Claim No. 3 in Edison's Specification. Now, it is
perfectly correct to say that we have in Pulvermacher's 1148
Specification a description of a carbon rod or thread
which, if taken by itself, is very like Mr. Edison's car-
bon filament mentioned in Claim No. 3, taken by itself,
but it is used by Mr. Pulvermacher in a totally differ-
ent way and for a totally different purpose. That,
as I understand Mr. Pulvermacher's Specifica-
tion, was to be applied, not to an incandescent
lamp, but to an arc light. The spiral in question was
to be coiled round an inner core also of carbon, there
being insulation between the two. It was not to be

1149 attached to wires at both ends. Of course that would be inconsistent with his notion of the arc light. Curiously enough, too, Mr. Pulvermacher's Patent deals with two modes of lighting, the arc light and the incandescent, and it is very remarkable that having described in detail this spiral rod or thread for the purpose of his arc light, when he comes to state what his mode of procuring the incandescent lamp is, he discards his carbon conductor altogether and resorts to metallic wire. Whatever likeness there may be between Mr.
1150 Pulvermacher's spiral rod and Mr. Edison's coiled carbon filament mentioned in Claim 3, it is perfectly clear to my mind that Mr. Pulvermacher was wholly unaware that the coiled thread of carbon could be applied for the purpose of incandescent lamps, because he certainly would not have discarded it when he came to make his incandescent lamp which is provided for in the very same patent.

Now, I am almost afraid to attempt another reference to Dr. Odling's evidence, but I think I have a
1151 passage upon this point under my hand: "Lamp E. F. 3."—that is the lamp I think Dr. Frankland had made under his inspection and produced,—"could not be made from Pulvermacher's Patent, nor from anything known prior to November, 1879, except Mr. Swan's lamps, which would have enabled a competent electrician to make one. (Q). Whence could he (that is the competent electrician) get directions which would enable him to make that filament? (A.) I thought he could have got it from Pulvermacher's specification,
1152 but I find that is not so. (Q). Anywhere else? (A). I do not call to mind that there is. For Pulvermacher's purposes a spiral must be of considerable size and thickness." Now, so much for the alleged anticipation by Pulvermacher. With regard to Mr. Lane-Fox I do not think it necessary to go at any length into the description of his proposed lamps or systems of lighting. It seems to me that the Solicitor-General was perfectly warranted when he said it was abundantly clear from the different specifications of Mr. Lane-Fox, that he had realized and knew of the elements that were neces-

sary to make a good incandescent lamp. I will illus- 1153
trate what I mean by one example—the necessity, for instance, of a high degree of resistance. I think those observations were perfectly warranted, and it is true that although, as I have followed them, when he comes to prescribe what he would use for the purpose of his own invention, Mr. Lane-Fox nearly always seems to refer to metallic wire as the conductor, and not to carbon. He does mention in one or more of his specifications a carbon conductor. Then, as I understand the matter, like Mr. Pulvermacher, when he comes practi- 1154
cally and finally to deal with the matter, he disclaims it and drops it out of his patent: Why? Evidently because he did not know how to make an efficient carbon conductor. The carbon conductor he describes he must have thought—and he says, in fact—was less desirable than the metallic, under all circumstances; and he did not know how to make one that would be better.

I now come, passing over the other matters to the alleged anticipation by Mr. Swan. It seems to me that 1155
his lamp is the only combination at all like Mr. Edison's. Other inventors, other men of science, may have described individual parts of the combination, but none of them has brought all those parts into combination as Mr. Edison has. The law I take to be clear, each individual part of a combination may have been known before, yet if the combinations of those parts be new, that combination may properly be the subject of a patent. But it does appear to me, that if Mr. Swan's conductor was practically the same thing as Mr. Edi- 1156
son's carbon filament, then we have in Mr. Swan's lamp and in Mr. Swan's lectures, I think, the whole of Mr. Edison's combination, and that before the date of Mr. Edison's specification. The question, therefore, is, and the main question to my mind—are Swan's carbon rod or pencil and Mr. Edison's carbon filament practically the same thing? Now, I think they are not. It is a question of interpretation and, *prima facie*, no doubt the meaning of words in a written contract is for a Judge. But where technical terms, words of art,

1157 are used the evidence of scientific witnesses and experts in the matter to explain the sense in which they are used in their opinion may be received. Accordingly each side has called a certain number of scientific witnesses, to whom has been put the question of the meaning of the words "carbon filament" in the Claim No. 2. It is said, that in the multitude of counsellors there is wisdom, but when those counsellors turn out to be equally divided in opinion, and when it turns out that the only opinion on which they agree, is that they agree to
1158 differ, I do not see how the Judge derives very much benefit or advantage from their evidence. Such is the case here. The witnesses on behalf of the Plaintiffs say in effect (I do not say the very words, but in substance) Mr. Swan's carbon rod or pencil is not only different from Edison's carbon filament mentioned in Claim 2, but it is totally and wholly different. The Defendants' witnesses say: "In our opinion these two things are identical." In these circumstances I must draw such a conclusion on the point I must draw as my
1159 own uninstructed mind will enable me to arrive at. To my mind, it does seem to me, that a carbon pencil or rod is a very different thing from a carbon filament. It is difficult to express exactly the whole process of reasoning by which I come to that conclusion. It seems to me to carry one a long way on the road to that conclusion to say that a rod or pencil is a rod or pencil, and a thread is a thread. There are however certain differences which are not difficult to explain. It appears to me clear that one of those differences between Mr.
1160 Swan's conductor and Mr. Edison's conductor is this: Mr. Edison's Conductor possesses a smallness of cross section combined with other properties which Mr. Swan's does not. Mr. Edison's conductor possesses a degree of flexibility which to my mind is not even approached by Mr. Swan's. I think I am again confirmed in this view by some evidence given by Dr. Odling, one of the Defendants' witnesses:—"Excepting Swan's" (he says) "I cannot point to anything in the anticipations in which any other than a rod or stick of carbon alone is described." In the lamp of Swan pro-

duced the conductor is a rod. Now, to show what he 1161
meant, he says in effect,—true it is a rod, but it is a filament also, and I refer to Mr. Swan's subsequent communications,—I forget to what meeting made, but made on the 1st of January, 1880, in which he calls his conductor a filament. Then you know as a matter of anticipation, that rather broke down in Mr. Odling's hands, because it is an anticipation about twelve months after the event. He goes on to say:—"As applied to a conductor exclusively of carbon, I cannot point out any anticipation of Edison's statement contained in 1162
the passage from line 23 to line 43, page 3, of the Specification." The statement to which he referred begins with the words: "Heretofore light by incandescence" and ends with the words: "Very high temperatures."

Now, I cannot help thinking, that at the time in question, not in January, 1880, but at an earlier period before Mr. Edison's Specification, had Mr. Swan known of the various advantages of Edison's carbon filament as used, his lamp would never have contained a straight 1163
rod fixed at each end, and by straight, of course, I mean lying evenly between the two points of junction—a straight rod so fixed to the ends of platinum wires. Moreover, I think that there is no evidence to show that before Mr. Edison's Specification he knew how to make a carbon conductor of anything like so small a cross section which would answer to the other requirements stated.

I refer to a communication made in January, 1880, as one in which he called it a filament. I think I was 1164
wrong.

Mr. Aston: I think it was in 1882. I did not interrupt your Lordship.

Sir Richard Webster: What Dr. Olding referred to was later.

Mr. Justice Butt: The first time I can find Mr. Swan's conductor spoken of by him as a filament is in his Final Specification of the Patent which forms one of the matters in this suit, and that is under the date of 1st July, 1880, Mr. Edison's Final Specification being

1165 some seven or eight weeks prior to that. He chooses to use it. What he read and what he did not read is unknown to me, but having at all events, if he had chosen to use it, the advantage of the knowledge conveyed to the public by Mr. Edison's Specification, it is true we do find Mr. Swan some weeks later calling his carbon conductor a filament. Now, a rose does not smell any sweeter for being called a rose, and the fact that Mr. Swan did subsequently call that rod a filament does not at all convince me that it was properly so
1166 called. I do not forget that it is also in evidence from one or two of the Defendants' witnesses—from Dr. Odling, I think, amongst the number—that electricians have adopted the word filament, and, as I understood him, applied it to all manner and kinds of carbon conductors in these incandescent lamps. That may be so. Words often become, when applied to particular trades or sciences, twisted from their original meaning. A dozen at one time meant twelve, but I am not quite clear what number it has not been held in the Courts
1167 to mean in particular trades. It certainly in many does not mean twelve or anything like twelve. So with regard to these matters an illustration was given. A portion of a very beautiful flower, I believe it was a tulip was produced, and I was referred to that portion of it which holds and supports the anther as a filament, and I was told that in botany that was universally recognized as the name for it whatever the thickness of the thing might be. So be it. It has acquired that name in botany just as these conductors have since
1168 among electricians acquired the name of filament, but I suspect it would be found they have acquired the name of filament since flexibility was introduced and rigidity was tabooed.

On the whole, therefore, I have come to the conclusion—first, that there is no sufficient reason for saying that this patent is invalid on any of the grounds suggested on the parts of the defendants; amongst others, of course, that there is no ground for the assertion that it has been anticipated, or, in other words, that it is not new.

In the next place, I hold that, attributing the mean- 1169
ing I have to Claim No. 2, there has been a clear infringement by the Defendants of that Claim. That being so, the decree I must make is that those of the Plaintiffs who possess the legal and beneficial interests —I suppose who are the assignees of Mr. Edison's Patent—are entitled to the relief they have prayed. With regard to the other Plaintiffs, of course the precise form I do not know, but they must be withdrawn or dismissed.

Mr. Aston: Action dismissed with regard to them. 1170
Then, my Lord, in the usual manner I have to make application that your Lordship will be pleased to grant a certificate that the validity of the Patent came in question. That is, Mr. Edison's Patent.

Mr. Justice Butt: Yes.

Mr. Aston: Next, my Lord, I have to ask that your Lordship will be pleased to direct an account of profits made by the Defendants by the sale of the article in question.

Mr. Justice Butt: That is prayed? 1171

Mr. Aston: Yes; that is the regular form.

Mr. Justice Butt: That I suppose is the regular form. That is included in the decree. It is one of the matters prayed.

Mr. Aston: I am making now only the formal applications. Then the certificate, my Lord, that the validity of the Patent came in question, will extend to the charge that the Plaintiffs have made with regard to infringement—that the Plaintiffs have proved three breaches. That is under the Statute. 1172

Mr. Machrory: Only proved the breach of one.

Sir Richard Webster: That does not make any difference for our purpose.

Mr. Aston: We have proved our breach as to Claim 2.

Sir Richard Webster: The proof is infringement of the Patent, and we are entitled to that.

Mr. Justice Butt: Yes.

Mr. Aston: Then there is one other question with regard to the lamps possessed by the De-

1173 fendants. I do not wish to deal hardly at all with the defendants in this case. They have in stock a number of lamps they would desire to sell. They may either hand them over to us or make such arrangements as they may think fit. We should be entitled to have them destroyed. We do not wish to deal harshly with them, and no doubt that matter can be arranged; but we are entitled, according to all precedent, to have either those lamps delivered up to us or to have them destroyed.

1174 Mr. Justice Butt: I suppose, if you press it, I must make the order. I will hear anything Mr. Charles has to say on the subject; but if it is pressed, I presume it is a thing that *prima facie* a patentee is entitled to ask.

Mr. Aston: I am only making formal applications.

Mr. Justice Butt: I do not want, of course, to make the decree any harder or harsher against the defendants than I am compelled to do. It is granting what I am bound to grant, if you ask it.

1175 Mr. Aston: Yes. Then I ask that the costs be on the higher scale.

Mr. Justice Butt: I must hear what Mr. Charles says on that. I do not know what the higher scale is.

Mr. Aston: My application is necessarily multiform though it is formal. Then the next is that your Lordship will be pleased to allow shorthand notes in a case like this.

Mr. Justice Butt: Upon that again I must hear what Mr. Charles has to say.

1176 Mr. Macrory: Evidence only.

Mr. Aston: My friend Mr. Macrory says it should be confined to the evidence. I quite agree to that.

Mr. Justice Butt: Oh, yes. I am quite sure of one thing. I dare say this case will go further, and although my note is what the Court of Appeal goes on, I am quite certain the Court of Appeal would not like to go on my note alone without some assistance from the shorthand notes. I cannot take a note of every word the Witness says, and I do not do it. I do it as far as I can.

Sir Richard Webster: They have been referred to. 1177
The higher scale certainly has been allowed in all these patent actions.

Mr. Macrory: You do not mean as between solicitor and client?

Sir Richard Webster: No.

Mr. Justice Butt: I should think so, subject to what Mr. Charles may say. It is of course totally different from costs between solicitor and client?

Mr. Aston: Yes.

Mr. Charles: My friend is asking for an order 1178
under the Judicature Act Rules of 1883—that is all.

Mr. Aston: That is all.

Mr. Charles: If your Lordship thinks it is a case in which the costs ought to be on the higher scale, I will not address your Lordship upon it.

Mr. Justice Butt: I think so. I am quite sure I should have given costs on the higher scale to you if I had felt myself able to give judgment for you.

Mr. Charles: Then I will not press that. With regard to Swan and Gimingham's, I ask your Lordship to 1179
dismiss the action, with costs.

Sir Richard Webster: With such costs as have been occasioned. I do not resist that.

Mr. Justice Butt: Such costs as have been occasioned by this charge of infringement, which would be the whole of their Claim—that would be the cost of disputing the validity of that.

Sir Richard Webster: Such costs as have been occasioned. I think the order has been in another case
in which there were two patents, which Mr. Macrory 1180
will remember, such costs as have been occasioned by the including of those two patents on which the plaintiff has failed, and that covers my friends' raising the question of validity which they are entitled to prepare for as well as the question of infringement.

Mr. Justice Butt: The whole costs occasioned by that claim?

Mr. Charles: The whole of the costs occasioned by the claims of Swan and Gimingham. Then I have respectfully to ask for a stay of execution.

1181 Mr. Justice Butt: I think so, I do not know that the infringement is to go on.

Sir Richard Webster: We are entitled to our Injunction, of course.

Mr. Charles: I will say a word about that.

Sir Richard Webster: It is mixed up. If you say stay of execution you must say what you mean.

Mr. Justice Butt: Anything I can properly do to forward the Defendants on their way to the Court of Appeal I will do.

1182 Mr. Charles: I was going to draw attention to the order which was made on the motion for an interim Injunction in this case. That order was: "The Defendants undertaking to keep an account of all electric lamps made and sold by them until the trial, this Court doth not think fit to make any Order on this application." I should ask your Lordship to suspend the issue of the Injunction, we giving a similar undertaking.

Mr. Justice Butt: On those terms.

1183 Mr. Charles: On those terms.

Sir Richard Webster: That has never been done, and I must point out to your Lordship, respectfully, that you could not do so without, not only creating a precedent, but without going in the teeth of what the Court of Appeal has declared to be wrong. Your Lordship will forgive me for putting it in that way.

Mr. Justice Butt: I tell you if I am entitled to do it, I should do it, because I should wish to do it. You say I am not entitled.

1184 Sir Richard Webster: I say your Lordship cannot do that. What Mr. Charles has referred to is the order that is always made on an application for an interim Injunction where the Plaintiff has not a sufficiently strong case to get an interim Injunction; and then the Court says: "Well, if the Defendant will keep an account prior to Judgment, we will not do more than that;" but where final judgment has been given in favour of a patent, an Injunction goes as a matter of course, and Lord Justice Cotton pointed out only the other day, in a case in which my friend Mr. Moulton

applied, that is to say, in the Gas Engine case, that 1185
after final judgment the Court could not suspend its Injunction without stultifying itself.

Mr. Justice Butt: That is a thing I am not particularly anxious to do, if I have not done it already.

Sir Richard Webster: Your Lordship will not admit you have. The Court of Appeal may possibly say so, but if another action was brought to-morrow, we should be entitled to have an Injunction then, because the validity of the Patent has now been established in a Court of Law; and, that being so, as the late Mr. 1186
Justice Pearson said in that very matter, "How can you ask me to suspend an Injunction after final judgment, because if another defendant comes and infringes he could say, You cannot put me under an Injunction, because you have suspended the Injunction after final judgment. The Court of Appeal have put it, that where a judgment stands in favour of the validity of a patent, it is a consequence of that judgment that you shall have an Injunction. Just observe that it is only this: That the Defendants in going on to make lamps, if they 1187
wish, must do so by making terms with the Plaintiffs. That puts them of course in no worse position. They want to be able to go on as if they had not got a judgment against them after judgment has been pronounced. My friend has no precedent for it. There has never been a precedent for an Injunction being suspended where final judgment has been given.

Mr. Macrory: I will remind my friend of one case in which I happened to be.

Mr. Justice Butt: First of all, before you come to 1188
your individual case, will you tell me is it not the general rule not to stay the Injunction after final judgment.

Sir Richard Webster: You cannot deny that, Mr. Macrory.

Mr. Macrory: In Saxby vs. Easterbrook, the Judge said: "No, I should be doing an injury to the public."

Sir Richard Webster: Forgive me, that was mentioned in the Court of Appeal and the shorthand note

1189 referred to, and it is not the fact that judgment was suspended.

MR. JUSTICE BUTT: However that may be, supposing you are right, and there is one case in the multitude of cases, the fact that you can only produce one case in which this has been done proves to my mind a rule to the contrary. I need not say, that if you can arrange any terms which would delay the injunction, I should be very glad.

SIR RICHARD WEBSTER: It would so seriously affect
1190 the rights of the Plaintiff Company, quite independently of the particular judgment, that I must resist it with all the power that I can.

MR. CHARLES: Well, my Lord, I can only submit that under the circumstances of the case your Lordship would not be doing anything very wrong if you did suspend the issue of the Injunction.

MR. JUSTICE BUTT: I must do right where I can.

MR. CHARLES: Then I submit your Lordship would be doing right to suspend the Injunction pending the
1191 Appeal. It is quite true your Lordship's judgment is a final judgment, but directly that judgment comes under your appeal, although final in one sense it ceases to be actually final.

SIR RICHARD WEBSTER: Then go to the Court of Appeal, and ask them to suspend it. That is what Mr. Justice Pearson told them to do in the Gas Engine case, and sent them there, and the Court of Appeal declined to do it.

MR. JUSTICE BUTT: I really think Mr. Charles must
1192 go to the Court of Appeal, I understand that it comes to this that the rule is not to stay the Injunction.

MR. CHARLES: Then I must make a substantive application if so advised to the Court of Appeal.

MR. JUSTICE BUTT: I have given the best judgment I can, and I have formed my conclusion. It may be right or wrong, but I should be very sorry in the event of its turning out to be wrong, that the Defendant should suffer more injury from it than absolutely necessary, and therefore, my inclination would be entirely, if not inconsistent with other considerations, to stay

the issue of the Injunction, but I do not think I can 1193
do so.

MR. CHARLES: There is another matter with regard to what lamps the Injunction would apply. I have been told what your Lordship's judgment was, though I had not the advantage of hearing it myself. We make lamps of all sorts of resistances. I am informed that the judgment has been to the effect that the filament mentioned in Claim 2 is a filament of so many ohms resistance.

MR. JUSTICE BUTT: My judgment was given from 1194
notes. It is not nearly all that is written, but when I came to what I considered a critical matter, I put it down in black and white, for fear of an unruly member going beyond what was intended. I have exactly what I said upon the point, and I will tell you what it is. I can read it to you. I said shortly this—I do not propose to read the whole—"that to answer the description I thought and held that the carbon filament must possess flexibility and resilience, that it must be of small cross section offering a high degree of resistance to the 1195
passage of the electric current, and it must present but a small surface from which radiation of light can take place. "And then on your point what I said, and I am perfectly certain I read these words, was this: "I am disposed to think, but on this I refrain from giving a decided opinion, that the degree of resistance must be not less than 100 ohms, as mentioned on page 3 of the Specification." I do not feel certain about that, and I carefully guarded it in that way.

SIR RICHARD WEBSTER: I do not know whether my 1196
friend is going to make some subsequent application, but may I point out how impossible it would be for your Lordship to limit this Injunction by some measure even if you were disposed. You were describing the filament and I ask your Lordship kindly to look at page three of the Specification, from which those words are taken—the 100 ohms. What Mr. Edison there said was: I have discovered that even a cotton thread properly carbonised, and placed in a glass bulb exhausted to one millionth of an atmosphere, offers from

1197 100 to 500 ohms of resistance. That was a statement of the character of the carbon.

MR. JUSTICE BUTT: It was on that statement that I wrote down those words. I had it before me and looked at it.

SIR RICHARD WEBSTER: The resistance of the actual lamp in manufacture does not depend on the non-use of the filament. The filament would be the same, but they could alter the length of it. Therefore they would get the filament which exactly accorded with Mr. Edi-
1198 son's description, namely, we will say a length of three inches would present a resistance of 100 to 500 ohms, and then they would cut a shorter piece of that and say that it is not an infringement. I think I am justified in saying that your Lordship did not mean to decide that given the combination which takes the filament, it was not an infringement, because they cut the filament shorter. You cannot limit the Injunction in that way.

MR. JUSTICE BUTT: It was a point on which I saw some such difficulties as Sir Richard Webster suggests.
1199 Therefore, I carefully refrained, and I have got the very words before me. "I am disposed to think, but on this I refrain from giving a decided opinion, that the degree of resistance must be not less than 100 ohms."

MR. CHARLES: So that the judgment of your Lordship simply is that it is a filament of high resistance.

MR. JUSTICE BUTT: No, I will not say that, and other things.

MR. CHARLES: I am only talking of the question of
1200 resistance now.

SIR. RICHARD WEBSTER: We are not going to have judgment on one reason. We are going to have judgment on infringement.

MR. JUSTICE BUTT: I am infinitely less acquainted with these matters than the scientific witnesses who have been called, but I have one advantage over them, I am not subject to cross-examination. I decline to answer.

MR. CHARLES: The application that I make is, that

your Lordship would, in granting the Injunction, 1201
specify the *terminus a quo.*

MR. JUSTICE BUTT: It may be that I have decided that that was a necessary part of the description in Claim 2. It may be, I do not say it would be, that I ought to grant that application, but I have not so decided. I have carefully refrained from so deciding.

SIR RICHARD WEBSTER: Your Lordship would have been obliged to direct a report as to the secret process if that had been done.

MR. JUSTICE BUTT: The answer to my mind is suffi- 1202
cient that I have not really decided it. I have expressly said that I would not decide it.

MR. CHARLES: Then that is an answer to my application that the Injunction should be limited in the way I suggested.

MR. JUSTICE BUTT: You were not here when I read that part.

MR. CHARLES: No; I am much obliged to your Lordship for reading it to me.

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1205 IN THE COURT OF APPEAL.

ROYAL COURTS OF JUSTICE, JANUARY 31, 1887.

Present—LORD JUSTICE COTTON, LORD JUSTICE BOWEN, LORD JUSTICE FRY.

THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY

1206 VS.

WOODHOUSE AND RAWSON.

JUDGMENT.

LORD JUSTICE FRY: By the request of Lord Justice
Bowen I am about to read, in the first place, the judg-
ment of Lord Justice Bowen and myself, and not that
of Lord Justice Cotton. The plaintiffs in this action
1207 are the assigns of letters patent, dated November 10th,
1879, and granted to Mr. Edison for the invention
of and improvements in electric lamps, and in the
method of manufacturing the same. The de-
fendants are manufacturers of electric lamps,
and are sued for an infringement of the
patent. Mr. Edison's object, as stated in his
specification, was to produce electric lamps, giving
light by incandescence, which lamps should have high
resistance, so as to allow of the practical subdivision of
1208 the electric light. Mr. Edison, in his specification,
proceeds to state of what his invention consists. The
first element in his invention is the coiling or arranging
a light-giving body of carbon wire or sheets, so as to
make the resistance high in proportion to the light-
giving surface. The second element was the placing
of the light-giving body in a nearly perfect vacuum.
The third element was the conducting of the current
into the vacuum bulb through platina wires sealed into
the glass. The fourth element was the mode of manu-
facturing carbon conductors. The fifth element was
the mode of securing perfect contact between the me-

tallic wires and the carbon. After some statements as 1209
to the existing state of knowledge and invention, the
patentee proceeds in his specification to describe the
mode of carrying his invention into effect. The de-
scription is so far from being as clear as it might be
that we at one time doubted whether it was not studi-
ously and wilfully obscure, but on further consideration
we are not prepared to hold such to have been the
case, especially as the point was not urged by the ap-
pellants. It is not needful for us to pursue the de-
scription of all the processes given by the specifica- 1210
tion; but we will refer to the forms of carbon conduc-
tors described. The first form referred to as suitable
is "cotton thread properly carbonized," which is stated
to offer from 100 to 500 ohms resistance to the passage
of a current. The second form of conductor referred
to is any fibrous vegetable substance which will leave a
carbon residue after heating in a closed chamber. To
this class may be referred the "cotton and linen
thread, wood splints, and paper coiled in various
ways," to which Mr. Edison refers. The fourth form is 1211
"such fibrous material as before mentioned rubbed
with a plastic compound of blacklead and tar. The
fifth form is a carbon filament made of a combination
of tar and lampblack, or plumbago or carbon in other
forms, the tar being subsequently carbonized by being
subjected to high heat in a closed chamber." (Page 4
of specification, lines 1 to 40.) Mr. Edison observes
that small pieces of such a compound may be rolled
out in the form of a wire as small as $\frac{7}{1000}$ths of an
inch in diameter. The sixth and last form described 1212
is a carbon filament of the kind lastly described, but
coated for the purpose of support with a non-conduct-
ing, non-carbonising substance. By his specification
Mr. Edison makes four claims, namely: "(1) An elec-
tric lamp for giving light by incandescence, consisting
of a filament of carbon of high resistance, made as de-
scribed, and secured to metallic wires as set forth. (2)
The combination of a carbon filament within a receiver
made entirely of glass, through which the leading wires
pass, and from which receiver the air is exhausted, for

1213 the purposes set forth. (3) A carbon filament or strip coiled in such a manner that only a portion of the surface of such carbon conductor shall radiate light as set forth. (4) the method herein described of securing the platina contact wires to the carbon filament, and carbonising of the whole in a closed chamber, substantially as set forth." The first claim we understand to be for the entire lamp—that is, for all the elements of the invention brought together in one combination. It is conceded by the plaintiffs that the defendants
1214 have not used this entire combination, and, consequently, that there is no infringement on the first claim. The second claim is the one in which the real trouble arises, and it is necessary in the first place to ascertain its true construction. To us it has been extremely difficult to follow the learned counsel for the plaintiffs in the interpretation or glosses which they have presented in respect of this claim, because these interpretations and glosses have seemed to us not only to vary, but too vague. But in our opinion this claim ought to be con-
1215 strued with all the generality which its words seem to convey, so that it may be paraphrased as a claim to every combination of any carbon filament with any receiver made entirely of glass through which any leading wires pass, and from which the air is exhausted. The words, "for the purposes set forth," at the end of the claim may govern either the whole claim or qualify the antecedent word "exhausted." In the former case it described the exhaustion of the receiver as introduced for the purpose of preventing alike chemical and
1216 mechanical destruction from the presence of any gas—a purpose which Mr. Edison has enunciated and explained in the course of his specification. In this view the second claim differs from the first in not embracing the coiling or other similar arrangement which is the first element of the invention—nor the use of platina as distinguished from other leading wires—nor the mode of attaching the metallic to the carbon conductor. But this second claim embraces a combination of the five elements following, namely (1), a carbon conductor; (2), in the form of a filament; (3), a receiver wholly of

glass; (4), a vacuum; (5), the entrance of the leading 1217
wires through a glass receiver; the third claim is for that peculiar arrangement for coiling, or similar process by which a portion only of the carbon conductor radiates light; the fourth claim is for the attachment of platina contact wires to the carbon filament and the carbonising of the whole in a closed chamber, so that the third and fourth claims are those very portions of the entire combination which are not in the second claim; or in other words, the entire combination, the subject of the first claim, is subdivided into three sub- 1218
ordinate parts or combinations, the subjects of the second, third and fourth claims. It is satisfactory to find that the wide construction of the second claim was fully present to the minds of the counsel for the defendants when conducting the case in the Court below, so that in adopting that construction we are not running any risk of departing from the lines on which the case was fought in the first instance. There was distinct evidence of the utility of the combination contained in the second claim, not so far as 1219
was shown us, met by any opposing evidence. Indeed, the utility of the patent, and consequently of everything actually claimed by it, is not in dispute. Furthermore, it is not denied that upon the interpretation we have placed upon claim 2 the defendants have infringed it. The lamp W. and R., which was the subject of admission in the case, appears to us to be clearly an instrument made in accordance with the claim in question—it is a combination of a filament admitted to be carbon, with a glass receiver, admitted to embrace a vacuum, and with 1220
conducting wires passing through the glass. But then it is said by the defendants that the patent is wanting in novelty. It is not indeed contended that the entire combination of claim No. 1, or the subordinate combination of claim No. 4, has been anticipated, but it is urged that the combinations claimed in claims 2 and 3, according to the true reading of them, are not novel; that if novel, the second claim is expressed with a vagueness which is fatal to its validity, and that what was new in that claim is not a good subject of a patent.

1221 What then was the state of public knowledge on this
subject when the patent of November, 1879, was granted?
It was perfectly well known that light was to be produced in an electromotive current by resistance in
a conductor. It was further known that resistance
depended on four conditions or factors, namely: 1st,
temperature—a matter which, as it has not been
brought into consideration in this enquiry, we may for
the future disregard; 2d, the specific resistance of the
matter of which the conductor is formed; 3d, the
1222 length of the conductor; and 4th, its sectional area.
Furthermore, it was shown that from 1845 and downwards various attempts had been made to introduce
incandescent electric lamps, but there is no evidence
that any such lamp had been made with the exception
of two, which had been constructed and exhibited by
Mr. Swan. With regard to the lamp said to have been
made by Mr. Justice Grove in 1843 no evidence has
been given to us. The problem before Mr. Edison was
to find some conductor in which he could obtain high
1223 resistance to the current with great durability—that is
to say, great capacity to resist disintegration by heat
and the absence of all disintegrating influences of any
gas whether such influences were chemical or mechanical. The high resistance he might obtain from any use
of the three factors already referred to, the specific
resistance, or length of the conductor, or its sectional
area. As we have already seen, Mr. Edison satisfied
the conditions of this problem by using carbon, a substance of low conductivity, in a form in which the length
1224 of the conductor was great in proportion to its sectional
area, and by placing this conductor in a chamber not
occupied by an inert gas like nitrogen, but by
a vacuum as complete as is obtainable. The
importance of this combination can hardly be
doubted, for, if not alone, yet in combination
with other improvements, it has had this result
that, whereas before November, 1879, two or three experimental lamps were all that had been produced,
after that date such lamps have been produced by tens
of thousands and constitute a most important element

in our methods of lighting. In what ways did the 1225
alleged anticipations of Mr. Edison attempt to accomplish incandescent lighting? This point we shall first
investigate with regard to the second claim. The first
specification to which our attention has been called is
that of King in 1845. He proposed the use of two
kinds of conductors, metallic and carbon. The metallic conductor (for which purpose he proposed platinum), was to be made incandescent in the air. The
carbon conductor was to be used in a space from which
air and moisture were excluded. "To accomplish this," 1226
says the patentee, "in the most perfect manner it
"should be enclosed in a Torricellian vacuum." So
far as Edison uses carbon in the vacuum King was
evidently in anticipation of him. It becomes necessary, therefore, to consider with some exactitude how
King proposed to give effect to this portion of his invention. He explains one form of the apparatus only.
This consists of a barometer tube and column, but with
the upper portion of the glass tube enlarged so as to
contain in it the light-giving apparatus, which consisted 1227
of a piece of carbon of the kind found in the interior of
coal gas retorts, formed into a small pencil or thin
plate, but of a width as shown in the diagram, greatly
exceeding that of the conducting wires. The circuit
was to be made, beginning at the upper end by means
of first, a platinum wire sealed through the glass;
second, a piece of iron, *d*; third, the forceps attached
to the iron and to the carbon; fourth, the carbon;
fifth, similar forceps; sixth, a similar piece of iron, and
then, seventh, the mercury in the tube, or when this 1228
was depressed by the formation of vapour of mercury,
a copper wire passing from the lower piece of iron
through the mercury column. Now, comparing this
apparatus with the combination embodied in the
second claim of Mr. Edison, we find a carbon conductor and a vacuum; but we find that the carbon was
not required to be a filament—we find that it was placed
in a receiver made not entirely of glass, but partly of
glass and partly of the top of the mercury column, consequently that the leading wires were to pass, one

1229 through the glass and one through the mercury. Rob-
erts comes next with letters patent bearing date 1852.
This specification dealt with a wide range of the appli-
cations of electricity, and it is only a small part of his
specification which at present demands attention.
Roberts proposed to obtain electric light by passing a
current through a thin piece of graphite, coke, or char-
coal, or other infusible body being a conductor of elec-
tricity, while it was enclosed in a vacuum not containing
any oxygen or other matter which could cause the
1230 combustion or destruction of it. The apparatus by
which he proposed to effectuate this object consisted—
(1) of a glass globe fitted with a metallic cap turned
on its outside as a screw; (2) a hollow pedestal
furnished at the top with a collar into which the
metallic base of the globe screwed: (3) a tube furnished
with an appropriate stop-cock passing up the hollow
pedestal; (4) a piece of very thin graphite about
half an inch long, half an inch wide, and
as thin as might be, suspended in the globe
1231 between two metallic rods. The tube passing
through the pedestal served two purposes; in the
first place it was the means by which an air pump or
exhausting syringe was used to free the globe of air,
and in the next place it formed part of the line of
electric communication, for in this instrument the cur-
rent passed from the battery along this tube, then
along one of the metallic supporting rods, then along
the graphite, then down the other supporting rod
which passed through the metallic cap of the glass
1232 globe, but was kept from metallic contact with it by
ivory or other non-conductor. Now, comparing this
apparatus with the second claim of Mr. Edison, we
find that it differed in that Mr. Roberts did not use
carbon as his sole material, that he was content with
the exclusion of gases chemically destructive, and was
not alive to the importance of the mechanically de-
structive action of gases, that his receiver was not
made entirely of glass, and that the leading wires did
not pass through glass, but through the metallic cap of
the receiver. In 1874 or 1875 the Sprengel pump was

brought into use, and gave a great stimulus to all in- 1233
vestigations into operations carried on in vacuo, and
amongst others to electric lighting in vacuo. Mr.
Lane Fox's specification of October 9th, 1878 (No.
3988), is the first that demands attention. This in-
vention consisted in passing an electro-motive current
through a thin strip or wire of some suitable material—
Mr. Fox preferred an alloy of platinum and iridium. In
order to prevent the deteroriation of the material when
incandescent, Mr. Fox states that he sometimes sur-
rounds it with an atmosphere of nitrogen gas. That 1234
Mr. Fox's lamp had a great general similarity to the
one now in use cannot be doubted; but the most suit-
able material known to him, and the only one he men-
tions, is an alloy of platinum and iridium, metals which,
though of low conductivity as compared with many
other metals, have a high conductivity as compared
with carbon. He did not regard inclusion in a glass or
any receiver as necessary, and when he did use such a
thing he filled it with nitrogen gas. We have not car-
bon in the filament, not the glass receiver, and not the 1235
vacuum of Mr. Edison. In Mr. Fox's next patent,
dated October 12th, 1878 (No. 4043), he proposed the
combination of non-conductors with conducting sub-
substances. In the first form he retained his wires or
strips of metal (preferably the alloy of platinum and
iridium), but he coated them with an earthy non-con-
ducting material, such as lime, because at a given tem-
perature they seemed to radiate or give off more
luminous rays in proportion to the non-lumin-
ous rays than the platinum-iridium wire at 1236
the same temperature. In his second form
of conductor he employed asbestos or some
other non-conducting refractory material saturated or
impregnated with a conducting body, such as carbon
or iridium. In which ever of the two ways the conduc-
tor was constructed it was to be placed in a glass flask
hermetically sealed and filled with nitrogen gas. It is
obvious that in the first form of conductor we have a
metal and not a carbon conductor; in the second the
resistance is raised, not by the reducing the carbon to

1237 a filament, but by the intermixture of a non-conducting material with a conducting one, or by the subdivision and extenuation of the conducting material by the mode of its application to the non-conductor. We miss, too, the vacuum which was to protect the conductor from all mechanical deterioration. In short, we have not the carbon filament nor the exhausted receiver of Edison. A few days after the two patents of Mr. Lane-Fox a patent was granted to Mr. Van Choate (October 31st, 1878, No. 4,388), in respect of which he deposited a
1238 provisional specification only. The material to be employed by this inventor is vaguely described as "composed or formed of asbestos, mica, platinum or carbon, or any combination of them, and such other materials as may be required to give the proper affinity and homogeneity to the material." It is evident that this is no adequate description to enable any one without farther experiment to ascertain of what the conductor is to be made, or of what form it is to be. In the following month the industry of Mr. Lane-Fox results
1239 in his third patent (November 14th, 1878, No. 4,626). The point here relied upon by the appellants was the description of the conductor contained in the provisional specification. But in our opinion this was nothing other than a repetition of the second form of conductor described in Mr. Fox's specification to his patent of October 12th, and not then filed. There is no new light thrown on the inquiry by this provisional specification. In the same month of November, 1878, letters patent were granted to Mr. Pulvermacher
1240 (November 23d, 1878, No. 4,774). This invention was intended for use in an arc lamp, and though referred to for other purposes, it was not urged upon us that it contained any anticipation of the combination contained in the second claim. Next comes Mr. Lane-Fox's provisional specification of March 20th, 1879 (No. 1,122), which proposed to construct the incandescent portion of a conductor by a mixture or "combination of two highly refractory materials, one being a conductor such, for example, as plumbago, and the other of non-conducting or badly conducting material such as magnesia,

terconia lime, steatite or earthy matter, and he directed 1241
that the non-conducting material should be considerably in excess of the conducting material. The conductor was to be enclosed in a globe from which not all gas, but, as we read the specification, any gas or matter capable of effecting a chemical change in the luminous bridge, should be removed. It is evident that here we have neither the carbon conductor for the filamentous form, nor the vacuum of Mr. Edison. There is no evidence
that a single lamp made under any one of 1242
the specifications or provisional specifications we have referred to ever gave a ray of light. The rapidity with which the patents succeeded one another in 1878 and 1879 shows how keen was the race for the production of a good incandescent electric light, and the fact that no one of the inventors in question is shown ever to have succeeded seems to be strong evidence that every one of the ingenious apparatus which they devised resulted in failures. On the 19th December, 1878, Mr. Swan,
one of the present plaintiffs, exhibited to the New- 1243
castle-upon-Tyne Chemical Society a lamp constructed entirely of glass, containing in *vacuo platina* leading wires heremetically sealed into a glass, between which wires was suspended a rod or pencil of carbon, slender, but not so slender as to be described as a filament. This produced incandescent light for a while, and then the carbon rod bent or bulged downward in consequence, as it appears, of the electro-motive force being too great for the cylinder of carbon, and the inner side
of the glass was lined with a sooty deposit which, on 1244
examination, proved to consist of platinum, carbon and iron. On the 3d February, 1879, Mr. Swan, in the course of a lecture to the Literary and Philosophical Society of Newcastle, exhibited a second lamp of the same construction which gave out a very considerable incandescent light for some 20 minutes. It has been on exhibit in this case, and appears, like the first lamp, to have become to some extent coated on the inner surface with a dark deposit. On the 2d March, 1879, Mr. Swan again described his lamp to a Gates-

1245 head audience, but it does not appear that he exhibited it, and from that time it has, so far as this case is concerned, disappeard from history, and this disappearance is, we think, cogent evidence that Swan's lamp as it was exhibited was not a practical success, that Swan could not do what Edison did, and that the difference between a carbon rod and a carbon filament was the difference between failure and success. The result of this review of all the alleged anticipations of the second claim is to convince us that there was no case in which
1246 there were brought together all the five elements which we have pointed out as combined in Mr. Edison's second claim—carbon in a filamentous form in a vacuo, and in a receiver entirely of glass through which the leading wires pass. But as between Swan and Edison the difference is only between a rod and a filament, that is a difference of degree and of degree only. Mr. Edison has in his specification given no definition of a filament, and he has nowhere drawn the line between it and a rod. The specification is therefore
1247 itself argued bad as being too indefinite and vague. To this argument it may, in our opinion, be properly replied, that in a patent of this description definition is required only to such an extent as would enable a practical workman to construct the required apparatus, that there is distinct evidence that such a workman could make the required apparatus from the specification, that no witness of the defendants alleges that such a workman would have any difficulty, or would require any further experiments, and that the
1248 specification itself, as we have already shown, contains descriptions of six forms of filament, and those descriptions, it is obvious, would afford material assistance to any workman in doubt. It is urged that a mere variation in the size of a part of the lamp is not the subject of a patent. It may well be that no patent could be sustained for the use of a filament of carbon alone; but when that filament is part of a combination which is useful, and replaces a rod in an earlier apparatus which was useless, we can see no reason why the new useful combination may not be the good subject of a patent.

It was strongly argued that the mere change of the size 1249
of a part of the combination cannot constitute a new manufacture so as to be the subject of a patent. In most instances this may be true, but the present case is peculiar. Two, and, so far as we have learned, only two, specimens of the earlier form of the instrument have been constructed, and in both of those a rod and not a filament of carbon had been adopted. Mr. Edison used the filament instead of the rod for a definite purpose, and by the diminution of the sectional area made
a physical law subserve the end he had in view. The 1250
smallness of size, therefore, was no casual matter, but was intended to bring about, and did bring about, a result which the rod could never produce, and so converted failure into success. The point upon which Mr. Edison's instrument departed from Mr. Swan's was crucial, and the departure, though slight, had all the merits of a new invention, and produced a new apparatus. Three cases were cited to show us that a mere variation in the size of the carbon conductor will not constitute the good
subject of a patent. The first was Kay vs. Marshall, 1251
where the improvement claimed consisted in placing two rollers nearer to each other than they were previously used; but, in practice, before the patent, the distance between these rollers had been varied according to the fibre of the substance to be spun. The invention, therefore, was for the use of a well known machine in a manner in which it could have been previously used. To grant letters patent for such an invention would have deprived the public of the means of
using a machine which they had previously enjoyed. 1252
In Ralston vs. Smith (11 House of Lords cases, 223), the patentee claimed to have invented improvements in embossing and finishing woven fabrics, and in the machinery employed therein, and the House of Lords held in substance that all that was described in the specification was a new use of an old machine, and that this was not a new manufacture within the statute. In Patterson vs. The Gas Light Company, Limited (2 Chancery Division, 812), the Court of Appeal held that the invention claimed was only an invention for the

1253 more beneficial working of an old process, and that this was not a new manufacture. It does not appear to us that any of these decisions show, or tend to show, that the introduction into an old combination of a new shape of one of the old elements of that combination which invokes a law of nature, otherwise left on one side, may not be the good subject of a patent. For these reasons we are of opinion that the objection to the second claim fails. With regard to the third claim which relates to the peculiar arrangement adopted by
1254 Mr. Edison by which he reduced the light-giving surface of the carbon in proportion to its length, it was contended that this was anticipated by the publication of the specification of Van Choate and Pulvermacher. Van Choate, it will be remembered, proposed to employ a substance composed or formed of asbestos, mica, platinum, or carbon, or any combination of them, and such other material as might be required to give the proper affinity and homogeneousness to the material. The substance, he further says, was preferably made into
1255 wire or ribbon, and formed into arcs, spirals, or spiral globe-shaped illuminators or burners, or the material might be formed into discs or globes, or spirals wound round a central wire or body, or into other shapes required to form a light. It is obvious that the purposes for which Edison uses a coil, namely, the diminution of the radiating surface and the raising of the specific heat of the whole were not only absent from the mind of Van Choate, but would not result from large spirals which are manifestly within his provisional specification.
1256 In Pulvermacher's invention a spiral or screw-shaped rod was used, but this was for the purpose of illumination, not by incandescence, but by the voltaic arc, and consequently it had no real relation to the coil of Mr. Edison's lamp. For these reasons we are of opinion that the third claim was not anticipated. In the result the appeal in our judgment fails.

LORD JUSTICE COTTON: I am unable to agree with that, which is the judgment of Lord Justice Bowen and Lord Justice Fry; and I differ from them principally on the question of the construction of this specification.

Of course, differing from them as I do as regards the 1257
construction of this specification, I should say that if I agreed with them I should differ from them, as I shall hereafter point out, as to the effect of Swan's lamp. The question turns on claims 2 and 3 really, because those are the points on which it is said there has been an anticipation. As regards claim 3, I put that aside, because I agree with Lord Justice Bowen and Lord Justice Fry that Van Choate's is no anticipation of the spiral described in this specification. But the question
then comes as to the second claim, and I shall confine 1258
myself to that, but for this, that the construction put by the other Lords Justices on the first claim in my opinion has an effect, and an erroneous effect on the true construction of claim No. 2. The only question arises as regards the second claim; but then to construe that properly we must see what was the proper construction of the previous patent. Lord Justice Fry has said that in the opinion of himself and Lord Justice Bowen that is a description of the whole combination
which is described in the previous part of the 1259
specification. In my opinion that is erroneous; I cannot agree with that. What are the words of it? "I claim as my invention an electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance made as described and secured to metallic wires as set forth." Now, that entirely omits the globe, which was to be a vacuum, and in my opinion is confined to that which he has previously said is part of his invention and the
material part of it, that is to say, constructing a 1260
filament of high resistance as described and securing that to metallic wires as set forth. In my opinion, although if this were well drafted it would be proper as a matter of good drafting to put the whole combination either first or last, yet there is in that first claim simply a claim to the incandescent portion of the lamp. He calls it lamp, but he means the incandescent portion of it, consisting of a filament made as described and secured as described to metallic wires. There is nothing about a vacuum, and nothing about the glass globe

1261 in which this was to be. I may mention that when he describes how it is to be made he first of all connects his filament with the wires, and then he puts that, after it is so constructed into the globe, from which he exhausts the air. I mention my difference from them on that point because I think that rather leads them to the view they take of this second claim. If the whole combination had been claimed beforehand you might expect the second to be something different; but the second is clearly and simply a claim to a combination.
1262 What is it? A combination of a carbon filament within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted for the purposes set forth. Now, my only difference from them is as regards what there is meant by a carbon filament. Their view is that that means anything which can be called a carbon filament. Now, I differ from that. What is the general purpose and object of a claim? Its general purpose and object is that the patentee may show how much of that which he
1263 has described in his specification he claims as protected by his patent. It must be construed in my opinion with reference to that which he has already stated in his specification when he is defining the invention for which he has taken out a patent, and how the invention may be carried into effect. As a general rule the object is to say, "Notwithstanding what I have described, all that I claim is," so and so, and to limit, therefore, his claim to a certain portion of that which he has previously referred to in describing his inven-
1264 tion. It may be, and frequently is, that where a patentee has described in his specification a certain particular mode of carrying into effect his invention—as in this case in what he says about filament—he there says: "Now mind, although I have only mentioned beforehand certain specific forms of that which I call a filament, yet I claim everything which can be called a filament, and the combination of that with the other portions which I have described before." But here that has not been done. It is only the combination of a carbon filament. Would it be right, if we are to

construe this fairly, to say without reference 1265
to what the consequence may be, that he here claims the combination of anything which may be called a carbon filament with the other portions of his lamp. We must remember that at this time filament as applied to electric lamps was not a well-defined or known term. It is used, I agree, especially in the account we have had of Sidot's process; the word was used and it was not a new word. It was certainly used in botany, and although it was stated by the Attorney-General that this was a word of art employed at the time when this 1266
specification was filed, there was no evidence to show that it was. There is the difficulty in this case, as there must be in all cases where strides are made in the knowledge with reference to a particular matter, in separating knowledge at the time of the specification from the knowledge which exists in the minds of the witnesses and others at the time when the matter comes before the Court. The only way, really, of testing it is looking at the knowledge at the time of the invention; and there what we find is this, that this 1267
filament—that is my opinion—was not a word which had been defined in its application with reference to this matter at the time of the invention. When we come to one of the witnesses, Dr. Hopkinson tells us that it is a question of degree to decide where filament begins and where it ends. If this is to be in everything which is a filament, everything which is long and with the sectional area very small, then, in my opinion, there would be a great many difficulties as regards the validity of this patent. In the first place, if that was 1268
so, and filament only depends on a question of degree, not to be fixed as commencing and ending at any particular point, I cannot see how Swan's lamp was not an anticipation. There was a lamp with the exhausted receiver and a piece of carbon connecting the two wires which brought and took away the electric current, which made it part of the circuit, and thereby its greater resistance produced the light; it was of small sectional area, though certainly not such a sectional area as was used by either the plaintiffs or the defendants. But

1269 here, if this is to be applied to every filament, there being no particular mode of combination pointed out, as I put it to Mr. Aston during the argument: "Would you say that if this combination is used it matters not whether the filament is straight or whether it is curved, or whether it is wound into a spiral?" He answered: "Yes, I think it would." That being so, to my mind, if the construction, having regard to the indefinite use of the word filament (I am using it with reference to it being a mere matter of degree), then I should say that
1270 Swan's, which was not a mere unsuccessful experiment, but which produced a lamp which burnt without intermission and with good effect—the second lamp, I mean, because the first was spoiled in consequence of the current of electricity being too large—I should say, taking the construction which was put upon these words by the other Lords Justices that would be an anticipation of Edison's second claim. But that would not be the only difficulty. If that were the necessary construction of that, it is unnecessary to
1271 give a definite opinion upon it, because, in my opinion, it is not the true construction. I should have great difficulty in dealing with the objection to this patent that it is so vague and indefinite as to be bad; and I will mention here that I am not impressed as the other Lords Justices seem to be by the evidence of the witnesses that no competent workman would have a difficulty in carrying into effect Edison's invention. What they are referring to is the description given in the previous part of the specification, where he does dis-
1272 close a mode of carrying into effect his invention, and no doubt the evidence is, having regard to that, and looking to those filaments there described, that no workman would have difficulty in carrying it into effect; but they do not say that if this were to be applied to every filament then the workman would have known what was meant by the word filament—would have known at, or shortly after, the time of this specification—or that he would be free from difficulty and be able to carry it into effect without experiment. Really the questions are different. Then what is the claim?

What is the invention for which protection is claimed? 1273
With reference to that we must not look to see how far a workman would have any difficulty in working a previous description, but whether that claim is confined to that which is previously described, or whether it launches out into a variety of other pieces of carbon which are not therein referred to, and in my opinion, construing as I think one ought to do, the second claim with reference to the previous specification, and not applying it to everything which can be called a carbon filament, I think one ought to refer it back to that 1274
which has been referred to in the previous part of his specification as a filament, and one finds that in the beginning he speaks of carbon wires or sheets. "The invention consists in a light-giving body of carbon wire or sheets." And then he goes on with the coiling. On page four he refers to a filament as sometimes a wire and sometimes a thread, and in my opinion the proper and true construction of this second claim is a combination of a carbon filament, in substance such as is hereinbefore mentioned, with the other matters which 1275
he refers to in his combination. The whole of that second claim is very badly drafted, because it is the combination of a carbon filament within a receiver made entirely of glass—that is, the combination of a carbon filament with nothing, only in a receiver, but I take it the true construction, construing it fairly, is that it is the combination of a carbon filament with a receiver made entirely of glass. Then I come to the question, What is the result? And, in my opinion, the construction that I put on this specification establishes 1276
the validity of the patent; that is to say, prevents it from being held invalid either from vagueness or anticipation. But what is the result? Has there really been any infringement? There is a carbon filament undoubtedly in the lamp of the defendants. But now what is the essential part of a carbon filament as hereinbefore mentioned in the specification? In my opinion—and it was hardly contested—it was not confined to a carbon filament used exactly as described, and the judge held that there was no evidence that that had been

1277 done. The words are, "as described"; the description is of a particular way or particular ways of making carbon filaments, and really in the specification the greatest stress is laid on the coil or the spiral, so as to have a long filament of very minute sectional area. But what Mr. Aston said was this, that a filament necessarily implied flexibility and resilience. Now, I cannot find that at all in the specification, and of course we must look to the specification in order to see whether the filament, such as is mentioned, necessarily in-
1278 volves that flexibility and resilience. Flexibility, in my opinion, is contrary to the specification. There must be flexibility before it is carbonised; but we have to deal with the carbon filament after it is carbonised. There is nothing in the specification which require flexibility, or, as far as I can see, the resilience. But the Attorney-General, although contending for a more general sense of carbon filament in the second claim, said that it is every filament, subject to this restriction or qualification—if he put any—that it must be made into
1279 a filament before it is carbonised. At first I thought that there was nothing in the specification which would lead to that conclusion, but on looking carefully at it, it appears to me highly probable that the essential part of what he described in this specification as filament was, that it should be made into a filament, that is to say, into a fine wire or thread, or exist as a fine wire or thread before it was carbonised, and there are a great many passages in the specification, which is the only thing one would look to or rely
1280 on in a matter of construction, which will lead to that conclusion, because I find this on page 4. He describes how to make a very fine wire out of some plastic material, and then he shows how that is to be formed into a spiral. Then he says on line 8: "The spiral after carbonisation retains its form." Then he says what may be done to prevent the bit of wire which he has wound cracking during the process of carbonisation. It cannot be afterwards, because he says: "I sometimes roll a thread within the compound of lamp black and tar so as to allow of greater convenience in handling the

same." That must be before it is carbonised. "The 1281
flexible carbon filament is not so liable to crack by its own weight in the act of winding." It is not to be wound after the carbonisation, that is perfectly clear. Then on the same page, line 40, "Also lamp black, plumbago and carbon in various forms, mixed with tar, and kneaded so that the same may be rolled out into wires of various lengths and diameters; each wire, however, is to be uniform in size throughout. "If the carbon thread is liable to be distorted during carbonisation it is to be coiled between a helix of copper 1282
wires." Then he explains how the copper wire is to be eaten away after carbonisation. Then on line 51 he says: "With substances which are not greatly distorted in carbonising they may be coated with a non-conducting, non-carbonising substance, which allows one coil or turn of the carbon to rest upon and be supported by the other." There are other passages in the specification which show clearly that what was contemplated always was making a filament, and in these cases rolling it before carbonisation, and one finds this, 1283
that Sir Frederick Bramwell, who was the leading witness on the part of the plaintiffs, does recognize the importance of making the filament before carbonising it, and relies on what he thinks exists here, the filament existing before it was carbonised. I will not read his evidence, again, in this case, but on page 19, in answer to questions in the early part of his evidence, we find this: "Do you find in the specification that the filament is to be formed before or after carbonisation? A. Before carbonization." And then, I think 1284
in the re-examination, he sums up in these terms, in answer to questions of counsel and the judge as to what he thinks of great importance. "Mr. Aston: In not one of the prior specifications was there any other method of dealing with carbon intended to be used in any incandescent lamp other than shaping the carbon previously made and giving it the form it was intended to give it? That is to say, previously the burners, or whatever you like to call them, were carbon, and then you cut them into the form required by the person who

1285 was making the lamp. Mr. Justice Butt: There is nothing beyond shaping the carbon previously made? A. Where carbon alone is used I believe that is so. Where sticks and pencils and things of that kind are used, I think you will find they are made out of that which was carbon before they were manufactured. Mr. Aston: So that shaping was by means of a saw and file? A. A saw and file. Q. Edison does not make his filament in that way? A. No, he does not. Q. He makes it in various ways, forming the filament first and
1286 then carbonising it afterwards? Mr. Justice Butt: That is really quite clear on the evidence in chief, that he makes it of any fibrous material, and then turns it into carbon instead of taking carbon and sawing and filing it down." So that there, Sir Frederick Bramwell in the beginning and in the end of his evidence, the judge then holding that that was the result of all the evidence, points out specifically that in his opinion that was essential in regards what was called the filament or thread here—that there should be a filament
1287 formed, and that that filament should be afterwards carbonised. That being so, if the other Lords Justices agree with me in the construction to be put upon this specification, I think the proper course would be to ascertain by one of the ways offered on behalf of the defendants here, but so as not to divulge that which is their trade secret, how it is that the filaments, if they are to be so-called, which are used by them are in fact made. It was said by Mr. Aston, and in fact it was admitted in the course of the argu-
1288 ment, and was that which the whole argument and the evidence proceeded upon, that the filament of the defendant was made into that shape before it was carbonised; and there was a passage which no doubt very much supported that view, because at the end of Mr. Rawson's evidence there was a passage which was relied on by Mr. Aston as showing that that was so. It is at the end of his cross-examination. "Never mind what Edison has used. Your answer is quite sufficient. A deposit of carbon which is caused to be deposited so as to secure your filament to the platinum wire is a de-

posit of carbon put there after the filament is formed? 1289
A. Yes."

Mr. Aston: Yes, that is to form the terminals.

Lord Justice Cotton: Oh, yes. I quite understand that. I was going to explain that. The carbon filaments are joined by the defendants in a particular way, not that of Edison, to the wire and that is what Mr. Aston is speaking of. "Mr. Justice Butt: What is that answer? Mr. Aston: A deposit of carbon which Mr. Rawson says he employs to effect the junction of
his filament and platinum wires is put there after the 1290
carbon filament is formed. A. And carbonised. Mr. Justice Butt: The carbon he says is placed there after the filament is formed and carbonised? The Witness: That is, by carbonising I mean what is usually commercially spoken of as carbonising. It is different in our case, but it is called carbonising." There he is referring to the state of the filament before the junction is effected between the platinum wires and the filament, and if that is not carefully looked to it might be considered that he
was saying the filament was first formed and then car- 1291
bonised; but no, he says before the junction is effected the filament is a carbonized filament, and then only, and not after that has been performed is the junction effected with the platinum wires. In my opinion, if, as relied upon by Sir Frederick Bramwell, and as relied upon by the Attorney-General, the forming of the filament before it is carbonised is the essence which runs through all the filaments mentioned in the specification, the question ought to have been put pointedly in
cross-examination by the plaintiff's counsel to Mr. Raw- 1292
son: "I do not now ask about the time when you apply that which is to form the junction between the platinum wire and the filament. I do not ask about when that was done, but when do you carbonise the filament? Is it after the filament is made into a filament, or do you do it at the same time in some other way?" So that I say if the case rested on my opinion, I should desire to have that further evidence before I should say in this case, that, although the patent is good, there has been infringement. But as the other Lords Justices agree in a different construction, which would of course

1293 have a different effect on the evidence, the appeal here must be dismissed.

MR. ASTON: And dismissed with the usual consequences, my Lord?

LORD JUSTICE COTTON: Yes.

MR. ASTON: There is an arrangement made between Sir Horace Davey and myself, or the Attorney-General, that under certain terms the defendants may continue the manufacture of their incandescent lamps.

LORD JUSTICE COTTON: Do you mean continue gener-
1294 ally or pending the appeal?

SIR HORACE DAVEY: Pending the appeal, and it extended to both patents.

MR. ASTON: It did, and I propose that that should continue until the decision in the second patent is given. May I respectfully ask when that may be expected, my Lord?

LORD JUSTICE COTTON: I hardly like to say. I expected we should have given it by this time, but I have not had an opportunity of consulting with the other
1295 judges.

SIR HORACE DAVEY: Your Lordship will anticipate that the parties may desire—I don't say more than that—to go to the House of Lords upon this patent. In that case I shall probably be constrained to ask your lordships to suspend the injunction on certain terms.

LORD JUSTICE COTTON: It now stands suspended until the other judgment is given.

SIR HORACE DAVEY: Yes, my lord, but the arrange-
1296 ment between my learned friend and myself extends to both patents. My learned friends think that the more convenient course is that it should be continued. That is that the injunction be suspended until after the judgment is given in the Cheesbrough case.

MR. ASTON: On the same terms.

LORD JUSTICE COTTON: We hope that will not be long delayed, but that is all we can say now.

SIR HORACE DAVEY: Your lordships probably will not object.

LORD JUSTICE COTTON: Settle the terms between yourselves.

IN THE COURT OF APPEAL. 1297

ROYAL COURTS OF JUSTICE, FEBRUARY 18, 1889.

Present—LORD JUSTICE COTTON, LORD JUSTICE LINDLEY, LORD JUSTICE BOWEN.

THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY

vs. 1298

HOLLAND.

Judgment.

LORD JUSTICE COTTON: This was an action brought against the defendants in respect of two patents, both of which have become vested in the plaintiffs, and they sought to restrain the infringement of those patents. One of them was a patent granted to Cheeseborough. 1299
In respect of that Mr. Justice KAY decided in favour of the plaintiffs and granted an injunction and consequential relief. As regards the other patent, which was one obtained by Edison, and the date is the 10th of November, 1879, he decided against the plaintiffs, and hence the appeal. Now, this patent has been before this Court, and I had the advantage or disadvantage of being one of the members of the Court on the previous occasion. There was a difference of opinion between myself and the other Lord Justices as to the true con- 1300
struction of the specification, but I consider myself bound by the decision of the Court on that point, and, in my opinion, except on questions of fact, which, of course, must be decided by the evidence in this action, the Court ought to consider itself bound by the previous judgment. In the previous case the Court held that if there was no anticipation of the invention claimed by Edison it was a good subject matter for a patent, being for a combination many parts of which were not new, but which was rendered useful by a car-

1301 bon bridge or burner, described as a filament, which
the majority of the Court held not to be confined to
the particular things described as filaments in the
specification, but, I think, held that it must possess the
characteristics pointed out in the specification, must be
substantially the same as regards these characteristics
as the particular filaments described in the specifica-
tion. The Court then decided that the utility of the
invention was established. Then there was a great
effort made to contest the utility of the invention. This
1302 was principally based on the contention that no suc-
cessful incandescent lamps were made in accordance with
the specification of 10th November, 1879, and without
further improvements. Inventions for the improvement
of the carbon filaments followed quickly on the
patent of November, 1879, which greatly assisted in the
manufacture and durability of the burner of the incan-
descent lamp of November, 1879. That, in my opinion,
was a useful combination, and a patent is not to be de-
feated simply because subsequent inventions improved
1303 the patented article, or because in consequence of sub-
sequent improvements no article was in fact made in
accordance with the specification. But in my opinion
it is established by the evidence that in fact incandes-
cent lamps were made by Edison in accordance with
the specification of 10th November, 1879, and even sent
by him to Dr. Hopkinson, and publicly run by him in
March, 1880. I do not see any fact now brought be-
fore us which ought to induce the Court to depart, or
would justify the Court in departing, from the previous
1304 decision of the Court on the question of the invention
being useful, and being the good subject-matter for a
patent. But we then come to the objection of want
of novelty, which is a question of fact. The only al-
leged anticipation which I need consider is that of
Swan's lamp, "F. J. B. 1," exhibited in December,
1878, and February and March, 1879, by Mr. Swan. In
the previous case, on the evidence then before us, I
thought this lamp would, on the construction put by
the majority of the Court on the specification, be an
anticipation. How does the evidence now stand? It

is now admitted that the carbon burner of Swan's lamp 1305
was formed into its shape before it was carbonized;
and this removes one of the points much relied on by the
Plaintiffs in the former action. But we have now evi-
dence, which was not before the Court in the former ac-
tion, of what was being done by Mr. Swan and by Mr.
Stearn after the experimental trial of this lamp. We
have the evidence of Mr. Swan and of Mr. Stearn. We
have had before us the lamp "F. J. B. 1," and we have
the letters written by Stearn to Swan in 1879 and 1880,
which were apparently admitted by Counsel to show 1306
what was being done by Swan and Stearn. We see
that "F. J. B. 1" was treated by them as a failure, and
that their attempt to correct its defects led to lamps
which differed more widely than did "F. J. B. 1" from
the lamp described in Edison's patent. This evidence
assists the conclusion at which the Court arrived in the
former action, that Swan's lamp of 1879 was not a suc-
cess, and I think enables me to come to the conclusion
that this lamp was an experiment which failed and was
abandoned, and that the difference introduced by 1307
Edison was one which changed failure into success.
But it was contended by the Respondents that, in fact,
Swan had used for electric lighting incandescent lamps
with carbonised thread burners before the 10th Novem-
ber, 1879. Two witnesses, Proctor and Heaviside,
stated that carbonised thread lamps were, in 1879, used
by Swan. There is no ground for imputing dishonesty
to these witnesses, but there was direct evidence by
Swan that he did not make any thread-carbon lamp be-
fore 1880, or before a fire, the date of which is 1308
fixed as 17th January, 1880, and I am satis-
fied that the witnesses were mistaken in fixing the
date as 1879. Reliance was placed by the Respondents
on a lamp made by Bernstein, not as an anticipation of
Edison's patent, for it was not made till after 1879, but
as showing that Swan's lamp was a practically useful
one. But though Bernstein's lamp has a bridge or con-
ductor, a pencil of carbon like "F. J. B. 1," it has a dif-
ferent junction with the leading wires, which probably
obviates some of the difficulties which prevented Swan's

1309 lamp becoming a success. Then I come to an objection which was much relied on by the Defendants, which was not raised in the former action, and which is now supported by a great deal of evidence. The objection, taken as a whole, was that the specification did not sufficiently show how the invention is to be carried into effect. It is necessary that this should be done, so as to be intelligible and to enable the thing to be made without further invention; not as was pressed on us, by an ordinary workman, but by a person described by
1310 Lord Ellenborough in "Huddart vs. Grimshaw" (Webster's Patent Cases, pp. 85-87), as a person skilled in the particular kind of work, or as said by Lord Loughborough, in "Cartwright vs. Nightingale" (Webster, p. 6), a person conversant in the subject. But in my opinion it is not necessary that such a person should be able to do the work without any trial or experiment, which, when it is new or especially delicate, may frequently be necessary, however clear the description may be.

1311 One of the principal subjects of attack was that part of the specification which gave directions for making a combination of lampblack and tar to form a material to make the filament to be carbonised. Before the experiments which, by the direction of Mr. Justice Kay, were made under the supervision of Prof. Stokes, the Defendants' witnesses said that useful filaments could not be made out of the material, and Professor Crookes was particularly strong in his ridicule of the idea that tar putty could be pratically useful. Gimingham, a
1312 young man in the employ of Plaintiffs, produced and proved lamps with burners made of tar putty filaments, and after the experiments made before Professor Stokes the Defendants contended before us, without any support from the evidence, that the material could not be effectually prepared without a trade secret which they said had only recently, during the course of the trial of the action, came to the knowledge of the Plaintiffs, and probably had been communicated from America. It was said that the secret was the necessity of kneading the material for a length of time, and with

the exercise of great pressure. In fact Gimingham 1313
had for the trial of the previous action made lamps with tar putty filaments which were made exhibits in this action, and though there are no express directions in the specification how this putty is to be prepared, it is stated that the material can be rolled into threads as small as 7-1000ths of an inch, and I think it would be obvious to any intelligent workman who wished to prepare the material that it must be kneaded so as to make it perfectly homogeneous, and to prevent any breaking of the thread in consequence of 1314
any particle of lamp black not being perfectly amalgamated with the tar.

I think that this objection fails.

But it was contended that lamps with tar putty filaments had not sufficient endurance to make them practically useful. No point was made of this before Professor Stokes, so that no experiments were made to test this question. In fact, on the evidence before us, many of these lamps were shown to have run for a sufficient time to prove that they could not be considered 1315
failures in this respect. Another objection taken to the specification was that no sufficient directions were given as to the carbonisation of the filament. The specification says, page 3, "a cotton thread properly carbonised," and speaking of the thread of tar putty, that the "tar may be carbonised in a closed chamber by subjecting it to a high heat," but no directions are given as to how this is to be done.

Before the experiments made under the supervision of Professor Stokes, it was said that carbonising the 1316
filament in a closed chamber without any packing or with a packing of sand, which was suggested by Sir F. Bramwell, was impossible, as the filament would be reduced to ash. But this was proved to be unfounded, and before us it was still contended that no sufficient directions as to the mode of carbonisation were given. Carbonisation was a well known term. The ordinary process may be described as roasting without the presence of oxygen. This was well known and practised before the date of the patent, and Sir Frederick Bram-

1317 well in his evidence said that any person who knew the ordinary process of carbonising would succeed in carbonizing filaments. But it was strongly contended by the Defendants, and by some of their witnesses, that such slender things as filaments could not be carbonised in a closed chamber without being protected by packing, which the specification did not direct to be adopted. In fact, filaments were, as sworn by the witnesses of the Plaintiffs and demonstrated by the experiments made before Professor Stokes, successfully carbonised
1318 in closed crucibles or boxes without any packing; moreover, though the specification says nothing about packing, any skilled workman conversant with carbonisation would take the ordinary process of packing to exclude oxygen, and would, I think, know that when so delicate an article as a filament is to be carbonised, the greatest care would be necessary to prevent any possible access of oxygen. It is true that there was no trade in carbonising anything so delicate as these filaments, but great care only in exercising a known
1319 process and applying it to an unusually delicate article, and no invention would be necessary. When the Defendants' witnesses failed in carbonising the filaments, I think that they did not use reasonable care to exclude oxygen as shown in the case of using porous crucibles. I am of opinion that this objection also fails.

Another point urged by the defendant was that the coating with a non-carbonisable substance was injurious. The result of the evidence is that when the
1320 coating is a thin one the process can be and is done without any injurious results. But then it was objected that the specification did not direct the thin coating; and it was objected and so held by Mr. Justice Kay that this thin coating was a mere pretense of coating, and that it was dusting only. But it appears from the evidence of Mr. Crookes that he had himself, in fact, adopted the same method as was adopted on behalf of the Plaintiffs for this coating. The process was, I think, in the specification, proposed as preventing the filament of tar putty from sticking together

during the process of carbonisation, and what I have 1321
said about Mr. Crookes, I think, shows that the process which produced the so-called dusting must be considered as that which would naturally be adopted. I think that this objection also fails.

I have dealt with the principal points urged by the Defendants, though shortly, in order to avoid the extreme length which would be necessary if I were to deal minutely with the various points. In my opinion, the Plaintiffs are entitled to judgment and the appeal
must be allowed. 1322

Lord Justice Lindley: The validity of the patent in question on this appeal is disputed on two broad grounds, viz., 1st, because the patentee has not particularly described and ascertained the nature of his particular invention. Secondly, because he has not particularly described and ascertained in what manner the same is to be performed. The 9th Section of the Patent Act, 1852 (15 & 16 Victoria, chapter 83), under which the Plaintiffs' patent was granted, imposes upon
the patentee the necessity of complying with both of 1323
these conditions in order to sustain his patent, and the patent is bad if he fails to perform either of them. The two conditions, although often confused and overlapping, are really distinct, and it is always necessary to keep each clearly before one's mind and not to commit the mistake of supposing that compliance with one is necessarily compliance with the other.

The first condition imposes upon the patentee the necessity of stating in clear and intelligible language
what his invention really is so that others may know 1324
what addition the patentee has made to what was known before, so that they may know what they are not at liberty to do without his consent during the existence of the patent; in other words, so that they may know what the monopoly is that is granted to the patentee. The nature of the invention must be stated both in the provisional and in the complete specification; but whilst it is sufficient in the provisional specification to state the nature of the invention in general

1325 terms, it is necessary in the complete specification to "particularly describe and ascertain it."

The second condition imposes upon the patentee the necessity of stating in clear and intelligible language in which manner the patented invention is to be performed; so that others may learn from the specification how practically to avail themselves of the patented invention when the patent has expired; how they are to do what is necessary to carry out the new invention, the nature of which has been previously de-
1326 scribed. This condition applies to the complete specification only; there is no necessity to state in the provisional specification how the invention is to be performed.

With reference to the degree of clearness and distinctness of the language necessary to be used in order to comply with those conditions, it is obvious that no hard and fast rule can be laid down, the degree of clearness can only be stated in language which itself admits of considerable latitude in its application. On
1327 the one hand the patentee must make the nature of his invention and how to perform it clear and intelligible; on the other hand it is not necessary for him to instruct persons wholly ignorant of the subject matter to which his invention relates in all that they must know before they can understand what he is talking about. The patentee is adding something to what was known before; and he does all that is necessary, as regards the language he uses, if he makes the nature of his invention and how to perform it clear and intelligible to per-
1328 sons having a reasonably competent knowledge of what was known before on the subject to which his patent relates, and having reasonably competent skill in the practical mode of doing what was then known. In complying with the first condition, *i. e.*, in describing the nature of his invention, the patentee does all that is necessary if he makes the nature of his invention plain to persons having a reasonably competent knowledge of the subject, although from want of skill they could not themselves practically carry out the invention. In complying with the second condition, *i. e.*, in describing

in what manner the invention is to be performed, the 1329
patentee does all that is necessary if he makes it plain to persons having reasonable skill in doing such things as have to be done in order to work the patent, what they are to do in order to perform the invention. If, as may happen, they are to do something the like of which has never been done before, he must tell them how to do it if a reasonably competent workman would not himself see how to do it on reading the specification or on having it read to him. The principle to be ap-
plied to the language used to comply with the two con- 1330
ditions is the same for both; but one class of persons may understand only one part of the specification and another class only the other, and yet the patent may be valid. In a well drawn specification the two conditions that have to be complied with are kept distinct; but in many specifications this course is not pursued. The nature of the invention and the manner of performing it are often described together. It may be that one set of words sufficiently discloses both the nature of the
invention and the mode of performing it, as in 1331
"Boulton vs. Bull." But it may be, and sometimes is, very difficult to sever the two, and to see whether both are sufficiently described. Still, if they are in fact sufficiently described, the conditions must be held to be complied with, however difficult and troublesome it may be to arrive at the conclusion.

I have been induced to dwell at some length on the above matters, because of their importance to the present case, and of the danger of losing sight of the prin-
ciples by which the Court ought to be guided in decid- 1332
ing it.

I proceed now to inquire whether these two conditions have been performed; and I will take them in the order in which they logically present themselves. First, as to the nature of the invention. This Court has had to consider this patent before, and, although there was a difference of opinion amongst the members of the Court, the decision of the Court was, as I understand it—(1) That the expression "carbon filament", on which so much turns, was sufficiently clear and definite;

1333 (2) That the nature of the invention was sufficiently described and ascertained, and was summed up in the second claim; (3) That the second claim was in substance a claim to "every combination of any carbon filament with any receiver made entirely of glass, through which any leading wires pass, and from which the air is exhausted;" (4) That the Plaintiffs' "carbon filament" was essentially different from the carbon pencil used by Swan in his lamp "F. J. B. 1," and that Swan had not by that lamp anticipated the Plaintiffs'
1334 patent. The patent was upheld notwithstanding the very wide nature of the second clause as construed.

This decision is, in my opinion, binding on us so far as the construction of the specification is concerned, but no further. I do not regard the decision as binding us upon the questions whether the conditions to which I have alluded have been performed or not; for these questions depend not only on the construction of the specification, but on evidence as to the previous state of knowledge, and as to whether a person of rea-
1335 sonable skill could, at the date of the patent, carry out the invention without further instruction than the specification gave him. I have, therefore, whilst taking the construction of this specification as settled, considered myself at liberty to exercise my own judgment on the effect of the evidence in this litigation.

The construction of the specification which I consider binding involves three points, viz.:—1. That the specification is not too vague and unintelligible to be construed by the Court. 2. That what is meant by
1336 "carbon filament" is reasonably plain from the specification itself; and, thirdly, that the second claim as construed by the Court is not so wide as to invalidate the patent. The meaning of the expression "carbon filament" appears to me to be the crucial point for determination when dealing with the question whether the nature of the invention is particularly described. This point, moreover, is, in my judgment, by far the most difficult in the whole case. Everything, I think, turns upon it; but as I was not a party to the decision and the case will probably be appealed, I think it desirable to state

that after much consideration and doubt I have come to 1337
the conclusion that what is meant by the expression "carbon filament" can be gathered from the instances given in the specification, and that what is meant is any thread which can be and is bent into the required form, and can be and is carbonised when so bent. The thread, as shown by the examples, may be a fibre or a group of twisted fibres, or, as is to be gathered from the tar lampblack instance, it may be an artificial substance pressed or rolled into thread or wire-like forms.
The evidence shows that at the date of the patent the 1338
expression "carbon filament" was new as applied to electric lighting. Its meaning, or, in other words, the sense in which it is used by the patentee, must therefore be gathered from the specification. The sense in which the patentee has used the expression "carbon filament" can, in my opinion, be gathered from the typical examples given in the specification and referred to in the judgment of Lord Justice Fry in the former case. At the top of page 253 the Lord Justice says,
"It is not needful for us to pursue the description of 1339
all the processes given by the specification, but we will refer to the forms of carbon conductor described. The first form referred to as suitable is a 'cotton thread properly carbonised,' which is stated to offer from 100 to 500 ohms resistance to the passage of a current; the second form of conductor referred to is any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber. To this class may be referred the cotton and linen thread wood splints,
and paper coiled in various ways to which Mr. Edison 1340
refers. The fourth form is such fibrous material as before mentioned, rubbed with a plastic compound of blacklead and tar. The fifth form is a carbon filament made of a combination of tar and lampblack, or plumbago or carbon in other forms, the lampblack and tar being subsequently carbonised by being subjected to high heat in a closed chamber. Mr. Edison observes that small pieces of such a compound may be rolled out in the form of a wire as small as 7-1000ths of an inch in diameter. The sixth and last form described is a car-

1341 bon filament of the kind lastly described, but "coated for the purpose of support with a non-conducting, non-carbonising substance." The size of the filament is not stated; but it is quite clear from the objects to be attained that it must be long and thin, and nothing more definite is necessary to be stated.

Having arrived at that conclusion, it follows that, in my opinion, the patentee has "particularly described and ascertained the nature of the invention."

The next thing is to consider whether he has suffi-
1342 ciently described "in what manner the same is to be performed." This is a pure question of fact, and is in no way touched by the previous decision of the Court. Mr. Justice Kay, however, has found this against the patentee. Having carefully attended to the evidence and to his judgment, I have come to the conclusion that I am unable to agree with him; and I cannot help doubting whether he would have arrived at the same conclusion if he had had the advantage which we had, of hearing the Attorney-General's reply to his oppo-
1343 nents.

The Defendants, in the first place, endeavoured to make out that carbon filaments could not be made as described by the patentee. The evidence on this point was so conflicting that Mr. Justice KAY called in an expert to assist him. This gentleman's report is absolutely conclusive in favour of the patentee, upon the question whether carbon filaments can or cannot be made as described. Beaten on this point, the Defendants contend that no competent workman could have
1344 made carbon filaments according to the specification, without further instructions than are there given. If it be meant that few competent workmen could make them without some practice, I think the contention is well founded; but this is not sufficient to invalidate the patent. If a person is told to carbonise a thread, and for want of thought or practice he takes a porous crucible for the purpose, and does not protect his thread and fails, when, if he had packed this crucible, or had taken a non-porous crucible, he would have succeeded, his failure can hardly be said to be the fault of

his instructor, if a little thought and consideration 1345
would have shown that a packed crucible, or a non-porous crucible, was the right one to employ. The fact that a workman may use a wrong tool when he has a right one, which a little thought will lead him to see ought to be used, does not warrant the inference that a specification is bad, if it does not tell him which tool to use.

Again, with respect to tar putty; the object to be attained is plain; the putty must be kneaded so that it
can be rolled out thin, without a break or flaw. Prac- 1346
tice alone can teach any man how long and how hard he must knead. If he stops too soon and fails, is it the fault of the patentee? I should say certainly not. A similar observation applies to coating with a non-conducting non-carbonisable substance. If the coating is made lightly by dusting, all goes well; if too much is put on, failure is the result; a little practice is all that is required. Mr. Crookes himself tried dusting as the most natural way of coating; and the unsuccessful
coating experiments were not repeated before Professor 1347
Stokes. I feel the great difficulty of describing, in words, the distinction between an amount of practice, without which failure is probable, but the necessity for which does not destroy a patent, and an amount of experiment and invention, without which failure is certain, and the necessity for which destroys a patent. The test, however, by which to decide such a question is, I think, to be found by asking whether anything new has to be found out, by a person of reasonably
competent skill, in order to succeed, if he follows the 1348
directions contained in the specification? If yes, the patent is bad; if no, it is good so far as this point is concerned. Practice is one thing; experiment and trial are something different. On this point I derived considerable assistance from the judgment of the late Master of the Rolls in "Plimpton vs. Malcomson," and from the judgments in "Simpson vs. Halliday," and "Macnamara vs. Cooke." It is settled that a patentee who does not disclose the best method known to him of carrying out his invention does

1349 not comply with the second of the conditions to which
I have before referred. But if a patentee says that
something must be done which a reasonably competent
man would know how to do, the patentee need not tell
him how to do it, nor warn him to be careful, and to
exercise such forethought and attention as the delicacy
of the process to be used, or the material to be employed
plainly demand.

The evidence upon the question whether at the date
of the patent a reasonably competent man could make
1350 carbon filaments without further instruction than is given
in the specification, or without further experiments,
was undoubtedly conflicting, and Mr. Justice Kay, who
saw the witnesses, came to the conclusion that further
instruction and experiment were necessary. The Attorney-General,
however, convinced me that on this
point Mr. Justice Kay was mistaken. I cannot myself
come to the conclusion that the patentee has kept back
any secret that he possessed by virtue of which he
could in 1879, make carbon filaments better than other
1351 persons possessed of reasonable skill, and who followed
the directions contained in the specification with a *bona
fide* desire to succeed. To insure success, all that is
necessary is carefully to follow the instructions there
given, bearing in mind the objects to be attained, and
that the filaments are extremely delicate and easily destroyed.
That is, in my opinion, the fair result of the
evidence; and the fact that Edison in later patents
gave particular instructions as to the mode of carbonising,
&c., only shows that he had then ascertained that
1352 those instructions were necessary to enable a competent
man to attain the desired results. It cannot, I
think, be inferred that in 1879, special instructions
were necessary to enable reasonably skillful men to do
what the specification of that date said must be done.
The evidence on this matter is no doubt conflicting,
but I cannot agree in thinking that the manner in
which the invention is to be performed is not stated
with sufficient clearness to support the patent. If this
were really true, it would have been found out long
ago, at least so far as carbonising is concerned.

There remain, however, two other matters for con- 1353
sideration—namely, novelty and utility. The novelty
depends on whether Swan's lamp, "F. J. B. 1" was an
anticipation, for I am convinced that Proctor and
Heaviside are wrong in the date they assign to the hair-
pin lamps made by Swan. The correspondence re-
ferred to by the Attorney-General is conclusive as to
this matter. The lamp "F. B. J. 1" was held by this
Court, in the action against Woodhouse, not to be
an anticipation of the Plaintiffs' patent, but it was then
supposed that the carbon pencil used in it was carbon- 1354
ised after and not before it had assumed its final shape.
This was a mistake, and was admitted to be so in this
action.

The question of anticipation must be considered
anew on the evidence before us. If Swan's lamp
"F. J. B. 1" had been a success instead of a failure, it
would, in my opinion, have been an anticipation of the
Plaintiffs' patent. The evidence, however, shows that
it was a failure, and that Swan had not got the key to
success. His own efforts to improve this lamp show 1355
that he was not thinking of filamentous incandescent
carbons, but of other matters. Still his lamp did give
light for a time, and was very near, though, in my
opinion, not quite an anticipation. It was, in truth, an
unsuccessful experiment. I agree with Lord Justice
Fry in thinking that the point at which Mr. Edison's
instrument departed from Mr. Swan's was crucial, and
the departure, though slight, had all the merits of a
new invention and produced a new apparatus. Re-
garding the lamp "F. J. B. 1" as an unsuccessful ex- 1356
periment, this part of the case is governed by the prin-
ciple of "Murray vs. Clayton," 7 Chancery Division, p.
570.

The question of novelty which I am now considering
is closely connected with, although really different from
the question as to the sufficiency of the description of
the nature of the patented invention. Given Swan's
lamp "F. J. B. 1," can it be said that Mr. Edison added
anything to what was known at the date of his patent,
and that he sufficiently described the nature of what he

1357 added? In my opinion he did; not, indeed, in words distinguishing his lamp from Swan's, but by giving and describing a new type of body to be rendered incandescent, or, if I may use such an expression, a new type of thread. One mode of trying this question is to ask whether any one would make such a thing as Swan's lamp "F. J. B. 1," if he took Edison's specification as his guide? I am convinced he would not; he would avoid and not reproduce Swan's carbon pencil, and would adopt Edison's type of carbon in the carbon fila-
1358 ment. The two may be made to shade off into each other until it becomes impossible to draw the line sharply between them; but this does not prevent a man from perceiving the difference between the two types, or from adopting the one which succeeds in preference to the one which fails.

There remains the question of utility. Edison's patent is said to be of no use; and the proof of this statement is said to be furnished by the fact that lamps are not made according to the patent even by Edison him-
1359 self. The utility of the patent must be judged by reference to the state of things at the date of the patent; if the invention was then useful, the fact that subsequent improvements have replaced the patented invention and rendered it absolutely and commercially of no value does not invalidate the patent. Such has been the fate of lamps made in the way described in Edison's specification. Such lamps appear to have been made and sent to England, but they were so soon improved that they
1360 at once ceased to be used in their original form. But lamps having the carbon filaments in combination with the other essentials mentioned in the second claim are in constant use, and their utility is proved by the fact that this particular combination is used by the Defendants, and by every one, in fact, who makes incandescent electric lamps. The utility of the patented invention, meaning thereby the above-mentioned combination, is incontestable; and Mr. Justice Kay's opinion to the contrary is, I think, to be attributed to the view he took of the construction of the patent, a matter which,

as I have said before, I consider settled by the previous 1361
decision of this Court.

Before concluding I ought to notice the very formidable objection taken by Mr. Justice Kay to the validity of the patent, on the ground that the second claim is for a monopoly of incandescent lamps containing a filament of carbon for a burner, and that such claim is far too wide, considering how much Edison had invented. Whether the view here taken of the patent is correct or not turns, in my opinion, on what Mr. Edison did when he introduced "carbon filaments." 1362
That was, I think, a new departure of the highest importance in electric lighting, and if this be so, the claim is not too wide. See "Househill Company vs. Neilson" (Webster, page 683).

For the reasons above stated I am of the opinion that this patent, construed as it has been by this Court, is valid, and that the appeal ought to be allowed.

Lord Justice Bowen: In order not to add more than is necessary to the voluminous literature on the subject of this patent, I will express my views as 1363
briefly as possible. As regards the construction of the second claim, I think we ought to follow, on principle, what has been already decided by the majority of the Court in the case of the former action, but as I retain the same opinion as I then formed, this point becomes less material. The patent appears to me to claim in distinct and unmistakable language every combination of any carbonised filament with any receiver of glass, through which leading wires pass, and from which the air is exhausted. Whether a claim so framed is too 1364
vague or too wide, or unfit to be the subject of a patent, or whether it is wanting in novelty or utility, constitutes an inquiry, which, in parts at all events, may be said to be bound up with questions of fact, and as far as all such points are concerned, I think it desirable to judge this Appeal *de novo* upon its independent merits.

Construing claim two as embracing all combinations such as I have mentioned, is it too vague? I see no reason to doubt that in the year 1879 the term filament, though new at that date as regards electric lighting,

1365 would nevertheless convey to the minds of ordinary persons of the class to whom this specification was addressed the idea of a slender thread or thread-like substance, and it seems to me that the specification indicates that the thread or filament was first to be formed and then to be subsequently carbonised. On page 2 of the patent, the thread is distinguished from a rod. "Heretofore light by incandescence," says Mr. Edison, "Has been obtained from rods of carbon. I have discovered that
1366 even a cotton thread, if properly carbonised," will produce the requisite effect. The instances given in the specification, which are enumerated in the judgment of Lord Justice Fry and myself in the previous Appeal, and in the judgment of Mr. Justice Kay in the present action, are illustration of the sense in which the term, which appears to me to be in itself intelligible is used. The term filament is nowhere defined. It is a descriptive term, not a definition. But it appears to me to indicate the nature of this particular factor in the com-
1367 bination in a way that describes and ascertains the nature of the invention so as to render it plainly intelligible to a skilled person of the class to whom the specification is addressed--language which embodies old law, but which is tersely expressed in Lord Herschel's judgment in the Basidche Anilin case (2. Appeal Cases). The merits of the filament, as distinguished from a rod, are manifest. The filament, or thread, has an extremely small sectional area; it is flexible before carbonisation, and resilient afterwards. It is true that
1368 these merits are not explained, but I know of no law which renders it incumbent on the patentee in such a case to explain them. It appears to me, moreover, to be proved, not only that every successful lamp since 1879 which is available for multiple arc lighting has employed a filament, but also that there is no proof yet that any filament cannot be adapted to the patented combination.

If this is so, why is the claim too wide? It is not the fault, but the virtue of the invention that it covers so large a field.

We have been pressed with the argument that the 1369
Edison patent is useless, and that no lamp in the market has been made exclusively on the patent of 1879 without the aid of subsequent improvements. Improvements of real value followed with great rapidity on the patent, and were naturally utilised. Their rapid succession does not destroy the legal validity as regards usefulness of the original combination to which such improvements were felicitously applied. The utility of this invention, which was admitted in the Woodhouse case, has been challenged in the present 1370
action, but I think unsuccessfully, and the evidence shows that lamps made solely on the patent will and do succeed, although subsequent improvements have been generally engrafted on the original design.

Was "F. J. B. 1" an anticipation? We know now what the Court did not know in the last action, that the carbon conductor in "F. J. B. 1" was formed before it was carbonised. Was it a filament? The question is one of degree. I doubt whether it is one, and I still more doubt whether any one who saw it would 1371
understand it to be such. But in any case I think "F. J. B. 1" never was more than an experiment which was unintellible on account of its failure and barren of all fruit, and which was regarded even by its inventor as practically valueless in the race. The correspondence between Messrs. Swan and Stearn shows, I think, to demonstration, that till the middle of the year 1880 Mr. Swan did not consider himself to be upon the right track. The dates put forward by the witnesses, Proctor and Heaviside, seem 1372
to be unreliable and inaccurate, and I think there is reason for believing that it was Mr. Edison's patent which led back the world of electricians to the true path. Certainly from the date of its exhibition the lamp "F. J. B. 1" disappeared from history, until it was exhumed for the purposes of the trial in the Woodhouse case.

With respect to the remaining points raised in argument before us, I have nothing to add to what has been said by my brothers. I think this patent constituted a

1373 new departure in electricity; that the specification sufficiently describes and ascertains the nature of the invention, and that no reasonably competent operator alive to the delicacy and care obviously requisite in forming and carbonising so slight a thing as a filament, ought without any exercise of invention, but with reasonable watchfulness only and fair good will to have been embarassed in making and carbonising Mr. Edison's filaments. The Appeal in my judgment should be allowed with the ordinary results as to costs; and I
1374 think I ought in conclusion to express my own personal obligation for the conspicuous clearness and ability with which this case has been placed before us at the bar.

THE ATTORNEY-GENERAL: My Lords, there are one or two matters which have to be dealt with. In all probability I think it would be better if my learned friends, the juniors in this case, would try to agree, and, if necessary, see one of your Lordships upon them.

1375 LORD JUSTICE COTTON: Will that be necessary? One reverses so much of the judgment appealed from as dismisses so much of the action as refers to the patent of November, 1879.

THE ATTORNEY-GENERAL: The first thing I have to ask your Lordships for is for the usual certificates.

Lord JUSTICE COTTON: Yes. The only certificate you want is that the validity of the patent came in question.

THE ATTORNEY-GENERAL: And that we have proved
1376 our breaches.

LORD JUSTICE COTTON: Yes, certainly. I have looked through it, and as far as I see that is all that is wanted.

THE ATTORNEY-GENERAL: I think we get our costs under Section 31.

LORD JUSTICE LINDLEY: I think you had that certificate before.

THE ATTORNEY-GENERAL: Your Lordship is quite right. I ask for a delivery over of the stock of infringing lamps on affidavit.

LORD JUSTICE COTTON: Yes. 1377

THE ATTORNEY-GENERAL: And an inquiry as to damages.

SIR HORACE DAVEY: That is by the defendants.

THE ATTORNEY-GENERAL: I have to speak about the third party directly. That raises a difficulty, and I do not know how my learned friend is going to deal with it. Now, my Lords, the Brush Company intervened, and the Brush Company fought the action.

LORD JUSTICE COTTON: They intervened?

THE ATTORNEY-GENERAL: They intervened as third 1378
parties. That was the matter I was about to refer to that your Lordships have not had before you. The action was originally brought against Mr. Holland, who was the contractor for the Albert Palace; the Anglo-American Brush Company appeared and said they would indemnify the defendants and under Rule 52, order 16, the action was tried. It was tried as between the plaintiffs and the defendants and the Anglo-American Brush Company, and the Order was in these terms: "The Court doth order"—it was on order of the 18th 1379
November, 1886—"The Court doth order that the Anglo-American Brush Electric Light Corporation, Limited, be at liberty to appear at the trial of this action, and take such part therein as the Court shall direct, and the said Anglo-American Brush Electric Light Corporation, Limited, shall be bound by the decision of the Court in this action in any question as to the above indemnity which may arise between the said Anglo-American Brush Electric Light Corporation, Limited, and the Defendants." Now, on the judgment 1380
being given for the Defendants in the Court below, Sir Horace Davey said this at page 1189:—"Your Lordship did not mention it; the American Brush Corporation are third parties; but I think it will be more convenient, as no question was raised as to that, that they be put in direct relation with the Plaintiffs, to which, I suppose, there will be no objection." My Lords, I should desire to argue also before your Lordships, or in some other Court, whether we are not entitled to have an injunction in this action as against the third

1381 parties. I do not know that my learned friend will dispute it; it is a case in which the third party would clearly be held to be estopped. I am not sure whether we are not entitled to further relief, but I do not know what view Sir Horace Davey would take about it without consideration.

LORD JUSTICE COTTON: Allow me to ask you, the third parties were made parties before Mr. Justice Kay, were they not?

THE ATTORNEY-GENERAL: Yes, my Lord.

1382 LORD JUSTICE COTTON: There is no particular direction as regards them.

THE ATTORNEY-GENERAL: No, my Lord, but I submit we are entitled to have an injunction as against third parties; of course, the injunction at present is only against the Defendants. They are parties to the action.

LORD JUSTICE COTTON: They were made third parties as regards both points.

THE ATTORNEY-GENERAL: Yes.

1383 LORD JUSTICE COTTON: There is nothing in this judgment as regards the third parties in respect of the Cheesbrough's patent, which Mr. Justice Kay decided in your favour.

THE ATTORNEY-GENERAL: I have had nothing to do with that particular matter, and I do not know how that was arranged. All I do know is that in the proceedings in the Court below the Brush Company appeared as third parties, and throughout conducted this matter; and I submit to your Lordships that when
1384 persons have come in in that way——

SIR HORACE DAVEY: I appeared for Holland and the Jablochkoff Company, who were the Defendants.

THE ATTORNEY-GENERAL: I think my learned friend, for the moment, is mis-instructed.

LORD JUSTICE COTTON: Who does Sir Horace Davey appear for here?

SIR HORACE DAVEY: My brief is endorsed on behalf of the Respondents.

THE ATTORNEY-GENERAL: That is why I venture to think it is a matter that has to be further considered.

We shall certainly submit that we are entitled to an in- 1385
junction against the third parties; I will not say to any further remedy at present, but I submit to your Lordships that there is no answer to us on the injunction. Whatever Mr. Justice Kay might have done, they have appeared and have contested as a party the validity of this patent, and they are estopped now, assuming your Lordship's judgment to stand, from denying the validity of the patent. They were the makers of the lamps. They came in and said, We made the
lamps, we have indemnified Messrs. Jablochkoff and 1386
Holland against any consequences of the sale of these lamps, and, therefore, we claim to defend. Mr. Justice Kay admitted them, and, therefore, they became parties to the action, the issue being then directly tried, I submit, between the Anglo-American Brush Company and the Plaintiffs.

LORD JUSTICE LINDLEY: Will you let me see that order which you read just now?

THE ATTORNEY-GENERAL: With reference to our
rights against third parties, I am perfectly willing to 1387
make either a substantive application to your Lordships or to consider it more carefully. I did not even know that my friend Sir Horace Davey was instructed to say he did not appear for the Anglo-American Brush Company.

SIR HORACE DAVEY: I did not say I did not; I say I do appear for the Defendants. I have now my brief before Mr. Justice Kay, and it is endorsed, to appear for the Defendants and third parties. In this Court I
am instructed to appear for the Respondents. 1388

LORD JUSTICE COTTON: Where is the notice of appeal?

SIR HORACE DAVEY: It is quite regular, and served on the third parties.

THE ATTORNEY-GENERAL: I am quite certain it will appear that Sir Horace Davey was instructed and did appear at the trial for the Anglo-American Brush Electric Light Company. He says no now. Beyond that you will observe that when Sir Horace was victorious he said: "The Anglo-American Brush Company are

1389 third parties, and I think it will be more convenient, as
no question is raised as to that, that they put in direct
relation with the Plaintiffs, to which I suppose there
will be no objection;" and then Mr. Bremner says,
"No, I think not." My impression is that they have
taken proceedings for the purpose of obtaining taxation
of the costs on these matters.

SIR HORACE DAVEY: My learned friend is mistaken.
I am sorry to interrupt, but I have now the order made
by Mr. Justice Kay before me. It is an order in what
1390 I conceive to be the perfectly regular form, giving the
proper relief in Cheesbrough's patent against the Defendants
and directing the taxation of the costs of the
Plaintiffs in the part in which they succeeded and taxation
of the costs of the Defendants, and of the Defendants
alone, of the part in which they succeeded, and
directing a set-off of one against the other.

THE ATTORNEY-GENERAL: I should like to ask whether
the third parties are not referred to in that Order? I
have not seen it, but it is a very strange thing if they
1391 are not. May I look? I think, my Lords, in this very
order they are recited as appearing.

SIR HORACE DAVEY: They have a right to appear
under the Order at the trial.

THE ATTORNEY-GENERAL: This is the order? "This
action coming on for trial."

LORD JUSTICE COTTON: That is the judgment under
appeal.

THE ATTORNEY-GENERAL: Yes, my Lord. "This
action coming on for trial on"—a fearful number of
1392 days, which I will not read to your Lordship.

LORD JUSTICE COTTON: Do not frighten us by that.

THE ATTORNEY-GENERAL: "And in the presence of
counsel for the Plaintiffs and Defendants and for the
Anglo-American Brush Electric Light Corporation,
Limited, third parties."

SIR HORACE DAVEY: That is quite right.

THE ATTORNEY-GENERAL: I merely mention the fact.
I did state that counsel in the Court below appeared
for the third parties. I made that statement, I was so
instructed, and I am glad to find that I was right.

"Upon hearing the writ of summons, particulars of 1393
objections and particulars of breaches."

LORD JUSTICE COTTON: What I am afraid of is that
you are introducing a new practice, not justified, by
the order or the Act of Parliament. These third parties
are not Defendants. If those who are with you
had amended, and made them Defendants, it would
have been different.

THE ATTORNEY-GENERAL: I told your Lordship, and
I spoke with perfect frankness, that I was not myself
clear as to what relief we were entitled to against these 1394
third parties. But as to one matter, the injunction, I
submit we are entitled.

LORD JUSTICE COTTON: That I doubt. You cannot
get an injunction except as against the Defendants,
their servants and agents.

THE ATTORNEY-GENERAL: Would your Lordship look
at Rule 54 of Order 16?

LORD JUSTICE LINDLEY: That is about costs?

THE ATTORNEY-GENERAL: "The Court or a Judge
may decide all questions of costs, as between a third 1395
party and the other parties to the action, and may
order any one or more to pay the costs of any other or
others, or give such direction as to costs as the justice
of the case may require." Therefore I humbly submit
—it is only a minor matter, although of some importance—that
I am entitled to an order for costs against
the third parties here. They defended in the Court
below; notice of appeal was given to them—I have the
notice before me—to let Renshaws, solicitors for the
Defendants, and third parties, the Anglo-American 1396
Brush Company, appear on the appeal. They would
have claimed their costs, therefore I am entitled to an
order for costs in the action, and on the appeal as
against the third parties.

SIR HORACE DAVEY: I am not aware of any rule
which enables a decree to be made against third
parties.

THE ATTORNEY-GENERAL: I say as regards costs—
Rule 54.

LORD JUSTICE LINDLEY: Rule 54 applies to costs.

1397 The Attorney-General: If ever there was a case in which the Plaintiff was entitled to have costs against third parties it would be this case. The Brush Company appeared at the beginning as Defendants, and conducted the whole matter on an indemnity, having indemnified the Jablochkoff Company and Holland; therefore, I claim as a simple right, an order, subject to your Lordship's better judgment.

Lord Justice Cotton: I have some little doubt about it, because in former days if such a thing had
1398 taken place one would have amended one's Bill, and made these persons, who are now third parties, Defendants, and then there would have been no difficulty.

Sir Horace Davey: Or sued them at once.

The Attorney-General: My understanding of this matter has been—I am only speaking now with great deference—that the object of these rules and orders was to prevent that.

Lord Justice Cotton: I had nothing to do with the rules and orders, but I do not construe them so;
1399 they may have so intended, but they have not said so.

The Attorney-General: Of course I am only submitting my point to your Lordships. I think it is a matter that does require a little more consideration than Sir Horace Davey rather indicated. I think it is by no means clear that some relief, and it may be the complete relief, cannot be given where a third party has appeared under these circumstances; but some relief is the point I am upon now. Will your Lordships kindly look at Rule 48 of the same order? "Where a
1400 Defendant claims to be entitled to contribution or indemnity over or against any person not a party to the action, he may, by leave of the Court or a Judge, issue a notice." I speak from recollection, my Lords, but, I believe the third parties either elected to come in, or were brought in under some such notice. I have not got it before me at present.

Sir Horace Davey: We were served with notice.

The Attorney-General: I think they elected to come in.

Sir Horace Davey: No; we were served with notice. 1401

The Attorney-General: Then Rule 49: "If a person, not a party to the action, who is served as mentioned in Rule 48 (hereinafter called the third party), desires to dispute the Plaintiff's claim in the action as against the Defendant, on whose behalf the notice has been given, or his own liability to the Defendant, the third party must enter an appearance in the action within eight days from the service of the notice." It will be found that these persons appeared in the action, 1402
and took out a great many summonses in their own name. "In default of his so doing, he shall be deemed to admit the validity of the judgment obtained against such Defendant, whether obtained by consent or otherwise, and his own liability to contribute or indemnify, as the case may be, to the extent claimed in the third party notice, provided always that a person so served, and failing to appear within the said period of eight days, may apply to the Court or Judge for leave to appear, and such leave may be given upon such terms, if 1403
any, as the Court or Judge shall think fit." Lord Justice Lindley has the order, I think.

Lord Justice Lindley: I think it was an indemnity, was it not?

The Attorney-General: They got leave to appear in the action.

Lord Justice Lindley: I know, but it was only for the purpose of indemnity, was it not?

Lord Justice Cotton: I do not think it was to appear in the action, but to appear at the trial of this 1404
action; that is different from appearing in the action.

The Attorney-General: They entered an appearance in the action. As I say, the matter must be looked at more carefully. "The application of the Defendants for directions consequent upon the Anglo-American Brush Electric Light Corporation, Limited; the party served with a third party notice, filed the 10th August, 1886, in this action pursuant to the order dated 6th August, 1886, having appeared to such notice, which upon hearing the solicitors for the Applicants, and for

1405 the Plaintiffs, and for the Anglo-American Brush Elec-
tric Light Corporation, Limited, was adjourned to be
heard in Court coming on this day to be heard accord-
ingly, and upon hearing counsel for the Applicants, for
the Plaintiffs, and for the said Anglo-American Brush
Electric Light Corporation, Limited, and upon reading
the said order dated the 6th August, 1886, two affidavits
of Walter Dawson, filed the 30th July, and the 11th
August, 1886, and the exhibits therein referred to, and
an affidavit of Charles Edmund Webber, filed the 12th
1406 day of August, 1886, and the said Anglo-American
Brush Electric Light Corporation, Limited, by their
counsel, admitted their liability" (your Lordship will ob-
serve no question arose), "to indemnify the Defendants
against all claims of the Plaintiffs in this action. This
Court doth order that the said Anglo-American Brush
Electric Light Corporation, Limited, be at liberty to
appear at the trial of this action and take such part
therein as the Judge shall direct; and the said Anglo-
American Brush Electric Light Corporation, Limited,
1407 shall be bound by the decision of the Court in this
action in any question as to the above indemnity which
may arise between the said Anglo-American Brush
Electric Light Corporation, Limited, and the Defend-
ants, but not further or otherwise. And it is ordered
that the costs of this application, and of the adjourn-
ment thereof into Court, be costs in the action." There-
fore, I submit to your Lordships that my friends can-
not deny their liability to pay costs, assuming your
Lordships to think there is no rule of justice for their
1408 not being so ordered.

SIR HORACE DAVEY: Whether we pay the costs through the Jablochkoff Company or direct to you I really do not care.

THE ATTORNEY-GENERAL: I think it makes a very substantial difference.

SIR HORACE DAVEY: It does not make any difference to us.

THE ATTORNEY-GENERAL: No, but if my learned friend will allow me to answer his interlocutory conversation the point is, I submit, that having tried this issue, I am

entitled to an injunction against the third parties. If 1409
your Lordships will look at Rule 52, "if a third party
appears pursuant to the third party notice, the defend-
ant giving the notice may apply to the Court or a
Judge for directions, and the Court or Judge, upon the
hearing of such application, may, if satisfied that there
is a question proper to be tried as to the liability of
the third party to make the contribution or indemnity
claimed, in whole or in part, order the question of such
liability, as between the third party and the defendant,
giving the notice, to be tried in such manner, at or 1410
after the trial of the action, as the Court or Judge may
direct." That turns on the question of the liability of
the third party on the indemnity. Now Rule 53 says:
"The Court or a Judge, upon the hearing of the appli-
cation mentioned in Rule 52 may, if it shall appear de-
sirable to do so, give the third party liberty to defend
the action, upon such terms as may be just, or to ap-
pear at the trial and take such part therein as may be
just, and generally may order such proceedings to be
taken, documents to be delivered or amendments to be 1411
made, and give such directions as to the Court or Judge
shall appear proper for having the question most con-
veniently determined, and as to the mode"—I ask par-
ticular attention to those words—"and as to the mode
and extent in or to which the third party shall be bound
or made liable by the judgment in the action." Now, I
submit, my Lords, that what was intended was this:
that where a real Defendant has come in as against a
nominal Defendant, and has appeared, it was intended
to give the Court power, the thing being tried *inter* 1412
partes, of making an order against them as though they
were the original Defendants. I am aware it is a new
point, but, at the same time, I respectfully ask to press
this on your Lordships' consideration, "as to the mode
and extent in or to which the third party shall be bound
or made liable by the judgment in the action." The
question of the validity, and the question of infringe-
ment has been fought, not between Jablochkoff and
Holland really——

LORD JUSTICE COTTON: To be bound in what respect?

1413 The order says: "Shall be bound by the decision of the Court in this action in any question as to the above indemnity which may arise between the said Anglo-American Brush Electric Light Corporation, Limited, and the Defendants," that is all.

THE ATTORNEY-GENERAL: I did not get them bound, that was, the Defendants. With great respect, I am now applying to your Lordships now for the order.

LORD JUSTICE COTTON: We cannot now make such an order. The order appears to be an interlocutory order
1414 under Rule 53.

THE ATTORNEY-GENERAL: It is, "The Court or a Judge."

SIR HORACE DAVEY: "Upon the hearing of the application."

THE ATTORNEY-GENERAL: I am quite aware that I have the privilege of answering you interlocutorily, but I am never allowed to object to it. What I am submitting to the judgment of the Court is, that this point is one of very great substance, because what happened in
1415 this case is that the Brush Company have been the real Defendants from beginning to end, and I will call your Lordships' attention to page 249 of the proceedings before your Lordships when Mr. Sellon was called, the electrician to the Anglo-American Brush Company. Mr. Justice KAY said: "These are the practical Defendants, are they not? (Mr. FINLAY): Yes, my Lord, the third parties." And no one was ever called from the nominal Defendants. I only ask your Lordships to say that you have power in such case as this, where a
1416 third party has appeared, to make the order for an injunction, at any rate, against them. Then, my Lords, I do not understand my learned friends to deny, now that your Lordships have the power to make an order under Rule 54, for costs, and I ask for an order under Rule 56 as to costs. "The Court"—that is your Lordships—"may decide all questions of costs as between a third party and the other parties to the action, and may order any one or more to pay the costs of any other or others, or give such directions as to costs as the justice of the case may require." My Lords, it has

a much more practical bearing on this case. It is not 1417
merely a question of so much money received through the hands of another defendant, but I submit to your Lordships that I am entitled to have an order as to the payment of the costs by the third parties, the Anglo-American Brush Company, who have contested this case from beginning to end.

If your Lordships wish this to be farther looked into, and further argued, of course, as I submitted to your Lordships in my opening observations, I should be glad to have time to consider it more thoroughly. I 1418
merely, perhaps being misled, thought the position of the Plaintiffs and the Defendants, which had been recognized throughout and relied on as long as the Anglo-American Brush Company were successful, would not be repudiated when they were unsuccessful; but, still, be that as it may, I do ask your Lordships to say that you have power to make this order, certainly under Rule 54, and I should submit to your Lordships also under the general powers of the Court. If your Lordships will look for one moment at Rule 49, the third 1419
party must admit if he does not appear, the validity of the judgment against the Defendant. The validity of the judgment against the Defendant is that the patent is valid, and if the Defendant has appeared it cannot be that a third party, who has appeared and tried the issue, could walk out of this Court, and go on infringing and put the Plaintiffs to the trouble of issuing a writ against them, and moving for an interlocutory injunction. Of course, it cannot be denied that it is an estoppel, because it has been tried 1420
as between us—this issue has been tried between us as between a party who has intervened in the action, and, of course, if you put them in the position of third parties having nothing to do with the action, there must be an interim injunction against them directly our writ is issued.

LORD JUSTICE LINDLEY: Has the question whether the Brush Company infringed ever been tried at all?

THE ATTORNEY-GENERAL: Certainly, the Brush Company made the lamps.

1421 LORD JUSTICE LINDLEY: They indemnified the other
people.
THE ATTORNEY-GENERAL: The Brush Company made
the lamps in question. A formal admission was put in
at the trial that the Brush Company made the lamps
and supplied them to the Jablochkoff Company, having
indemnified the Jablochkoff Company against any con-
sequences of making these lamps, and the *corpus delicti*,
and the only *corpus*, were the lamps which had been
made by the Brush Company. They admitted the
1422 lamps produced and the mode of manufacture, and the
whole case was conducted and fairly enough conducted
by the Brush Company; the Jablochkoff Company and
Messrs. Holland were simply names. I have indicated
the points to your Lordships; I do not want to argue
it further now, but I think if your Lordships are
against me it requires further consideration. At the
beginning of Mr. Justice Kay's judgment, he says:
"The Plaintiffs sue the Defendants for the infringe-
ment of two Letters Patent. The defence is taken up
1423 by third parties, the Anglo-American Brush Electric
Light Company." I shall ask your Lordships to really
direct and order that where such an issue has been so
raised, and tried this Court, assuming Mr. Justice Kay
to have given judgment for the plaintiffs—that is the
position which we are in—as, in your Lordships' pres-
ent opinion, he should have done—Mr. Justice Kay
could have awarded an injunction against both the De-
fendants and the third parties. That is my respectful
contention to your Lordships.
1424 MR. ASTON: I am on the same side and I shall have
very little to add to what has fallen from the Attorney-
General, but I should like to remind your Lordships
that this Court has on several occasions said that it has
full power over all the proceedings, being in the place
of the Court of First Instance.
LORD JUSTICE COTTON: Yes; there is no doubt about
that.
MR. ASTON: Then supposing in the Court of First
Instance this difficulty had arisen, and it had been there
said, Oh, there has been no formal proceedings in which

the third parties have been made really co-defendants, 1425
and we had then applied, it would have been done at
once?
LORD JUSTICE COTTON: I do not think you could have
done it at the hearing of the action; you ought to have
done it before.
MR. ASTON: At the hearing of the action all things
can be done.
LORD JUSTICE LINDLEY: Do you mean to say you
could give the plaintiffs liberty to amend by making
them defendants? 1426
MR. ASTON: Yes, my Lord; at the time there is noth-
ing to prevent it being done, and the object of all
these orders and all these rules, I submit to your Lord-
ships, is to simplify the proceedings. If we were ask-
ing anything that it was out of the power either of this
Court or of the Court of First Instance to do, or which
could not be done otherwise than by a roundabout pro-
ceeding, it might be different.
LORD JUSTICE COTTON: You see, when this order was
obtained—the order which has been handed up to me 1427
—which is dated Thursday, 18th November, it might
have imposed these terms on the third party, giving
him liberty to defend the action. It must be done, then
in my opinion.
MR. ASTON: All I say is, that is very true, but at the
same time, inasmuch as the third parties were let in at
that time, if we had then said: "Now at the trial we
ask for the proceedings to be so amended that there
may be no necessity for any further application in case
of success, but that they should be made co-defend- 1428
ants." I submit that would have been done at once.
LORD JUSTICE COTTON: It might have been done, but
now the Brush Company may take a different view.
They may have said: "We will submit to those terms
as the price of getting liberty to appeal," but they
have got that, and they do not want to pay that price
now.
MR. ASTON: I can easily understand, my Lord, if
there were any substantial advantage.
LORD JUSTICE COTTON: What is the object of all this?

1429 You do not want costs; you do not want any further security for costs.

MR. ASTON: No, we have got the costs.

THE ATTORNEY-GENERAL: We want an order for costs. Holland's people may not be sufficiently solvent. I should tell your Lordship that orders for costs have been actually made against third parties.

LORD JUSTICE COTTON: On behalf of the plaintiffs.

THE ATTORNEY-GENERAL: Yes, on behalf of the plaintiffs.

1430 SIR HORACE DAVEY: Under what circumstances?

THE ATTORNEY-GENERAL: I will give the circumstances. Under that very Rule 54.

LORD JUSTICE COTTON: It was held that costs could be given between third parties as against the plaintiffs. I do not know that it has been held that costs could be given to the plaintiffs as against third parties.

MR. ASTON: I am asking your Lordship to exercise a power you have to put the parties in the same position they would have been in had any irregularity or
1431 shortcoming in the Court of First Instance prevented them from having their just rights. Your Lordships, having those powers, you have to decide the mode in in which justice is to be done between the third parties and the other parties. Your Lordships will remember in the case of "Cropper vs. Smith" where there were two parties; one was a patentee and the other was his partner, and there was a question as to whether there should not have been an application for amendment before your Lordships, your Lordships intimated that you
1432 had power to put the parties exactly in the same position that they would have been in in the Court of the First Instance, and I submit that in this case all that would be required would be to say that an application that could possibly have been made and might reasonably have been entertained by the Judge of First Instance we will hear, and we will entertain and decide. That is the effect of all these rules and orders, as I submit to your Lordship, and the effect of your Lordship's judgment in "Cropper vs. Smith." Now, what would be the position of the parties here? It is quite clear

that the Brush people have infringed, because that is 1433
found—they supplied the lamps. On the next motion day before one of the Courts of First Instance, we should go for an injunction, and we should get an interlocutory injunction at once, and then the parties would be in exactly the same position as they are now. Why is it necessary to go through all that formality if your Lordships have power, and I submit your Lordships have? They are here now before the Court.

LORD JUSTICE COTTON: Why is it necessary to go through the formality of serving a Defendant with a 1434
writ?

MR. ASTON: I beg your Lordship's pardon?

LORD JUSTICE COTTON: Why is it necessary to go through the formality of serving a man whom you wish to restrain by injunction with a writ?

MR. ASTON: Because that is the regular course of proceeding.

LORD JUSTICE COTTON: So it is to make parties Defendants, if you wish to treat them as Defendants?

MR. ASTON: I quite admit; but if there are already 1435
existing proceedings in which that expense and trouble can be saved, subject, of course, to the rules and orders of the Court, I submit that it is in accordance with the practice, and in accordance with the intention of those rules and orders, that that unnecessary expense and roundabout proceeding should be avoided. Of course, *ab initio*, we must take that course; there is no other way of getting a Defendant before the Court; but if you have the Defendant before the Court, submitting and agreeing to be bound—— 1436

LORD JUSTICE COTTON: The question is, whether he is a Defendant here before the Court. That is the very point. You say, "If there is a Defendant here before the Court." If there is, your case is clear.

MR. ASTON: I mean, who would be a Defendant in another proceeding.

THE ATTORNEY-GENERAL: Would your Lordship look at your own judgment in "Hornby vs. Cardwell," 8 Queen's Bench Division. I am sorry to interpose, but, as I told your Lordship, I so entirely regarded the

1437 Anglo-American Brush Company as being the Defend-
ants throughout that I did not know—of course I was
wrong, and my learned friend, Sir Horace Davey, was
right—that this point would be raised, and I was not
prepared to argue it as I ought to have been. I began
by saying that that question of the minutes would have
to be considered, but I certainly think your Lordship,
in "Hornby vs. Cardwell," practically decided this
point in favour of the view which I submit. Your
Lordship says, at page 338: "The rules of Order 16
1438 are based on Section 24, Sub-section 3, of the Act of
1873, and their combined effect is that a third party,
when joined as such, becomes a party to the cause,
with all the liabilities of a party, and one of these lia-
bilities is the liability to pay costs under Order 55. It
is said that the use of the word "rights," in Sub-
section 3 of Section 24, exempts him from this liability.
But I think that the rights there referred to are the
rights which the third party might have to defend him-
self in another action. They cannot save him from the
1439 liability to costs in an action to which he is party.
The object of the legislation was to make the party who
had caused the litigation pay the cost of it."

LORD JUSTICE COTTON: Was not that where there was an increase of the costs of the action, caused by a third party coming in and raising a point?

THE ATTORNEY-GENERAL: I think not, and the view
taken by Mr. Justice Kay in "Pillar vs. Roberts," fol-
lowing on your Lordship's judgment, was distinctly
that the Court has power under Order 16, Rule 54, to
1440 order the third party so brought into the action to pay
the plaintiff the costs occasioned by his defence. The
whole of these costs are occasioned by the defence of
the Brush Company; the other persons never de-
fended. The moment they were served they served a
third party notice, and the Anglo-American Brush
Company came in. I again ask your Lordships to for-
give me for putting it before your Lordships in a
broken way, because I had not properly considered it,
and I should like to have put before you a considered
argument. I do ask your Lordships to hesitate before

you say you have no power to give relief against a 1441
third party who has appeared and acted as the par-
ticular third party in this case has.

In "Piller vs. Roberts," in 21 Chancery Division, Mr.
Justice Kay says: "If the point had not been decided
in the case of "Hornby vs. Cardwell," I should
still have come to the conclusion that the Court had
power to order the third party to pay costs. It appears
that on the application of Pinfold, an order was made
that he should be at liberty to defend this action, and
to put in a counter-claim. In pursuance of this order, 1442
Pinfold put in a defence and counter-claim. It is now
urged that the order ought to have imposed on Pinfold
under Rule 21 Order 16, that he should be liable to the
costs of action if the Court thought it right to order
him to pay costs. The only question, therefore, is,
whether it is necessary, in order to subject him to costs,
that the order should express that liability. But, in
my opinion, that goes too far, because if that were
required then it should go on to provide that he should
be subject to the judgment of the Court upon his case 1443
in other respects. If the Court gives him leave at his
own request to come in, it could only be upon the terms
that he should be liable to any judgment which the
Court should think fit to make against him. Surely it
is equally necessary that he should be liable to pay
costs if the Court thinks fit to award costs against him."
I am reading this with reference to the point your
Lordship threw out just now that it ought to have been
provided for on the original admission of the Anglo
Brush Company. "Surely it is equally necessary that 1444
he should be liable to pay costs if the Court thinks fit
to award costs against him." It was always the practice
in the Chancery Division that a creditor who came in
under an administration decree was liable to an order
for payment of costs, so also in winding-up cases claim-
ants have been allowed to come in, but if they chose to
do so it was always subject to an implied submission to
pay costs if they did not succeed. The third party
necessarily puts himself in the position of a defendant
both in respect of relief from and liability to costs.

1445 There is no case to the contrary, but in support of this view there are the cases of "MacAllister vs. Bishop of Rochester," and "Hornby vs. Cardwell." In the latter Lord Justice Cotton says: "The rules of Order 16 are based upon Section 24, Sub-section 3, of the Act of 1873, and their combined effect is that a third party, when joined as such, becomes a party to the cause with all the liabilities of a party, and one of these liabilities is the liability to pay costs under Order 55. It seems to be a direct decision that the Court has
1446 under such circumstances power to order a third party who comes in and obtains leave to defend, to pay the costs of action when the decision is against him. Here the Defendant not only got leave to defend, but to put in a counter-claim. I think the order giving leave to defend need not express that he must be liable to any order for costs, because that is implied. He has thought fit not to open his counter-claim. That I dismiss with costs to be paid by Pinfold." I should like the matter to be looked up, but what did happen in the action was
1447 the same as what happened in this.

Lord Justice Cotton: Do you mean in "Hornby vs. Cardwell," or in Mr. Justice Kay's case?

The Attorney-General: In "Piller vs. Roberts."

Sir Horace Davey: They got leave to put in a defence and counterclaim.

The Attorney-General: Nothing turns on the question whether they counterclaimed, because they did not open the counterclaim. In this case there was no counterclaim which could be alleged, be-
1448 cause the action was with respect to lamps which were made by the Anglo-American Brush Company. I think it has also been held, but as to that I should like to make a little further investigation before I assert it, that both discovery and inspection and interrogatories can be ordered against the third party.

Lord Justice Lopes: That happened in the other division.

The Attorney-General: My recollection is that in this case the Anglo-American Company got inspection.

Sir Horace Davey: No. 1449

The Attorney-General: I think it will turn out they got that inspection, too. The Anglo-American Company got inspection against the Plaintiffs, and certainly we got inspection against the Anglo-American Brush Company. I need not submit to your Lordships that there are no merits behind this. The whole question is as to the Anglo-American Brush Company. The only difference it possibly can make will be that in one event I shall have the great honour of the assistance of Sir Horace Davey, instead of being obliged to meet his 1450
arguments. I believe that is the sole difference of the particular name of the person who brought the particular action; but we have got the Anglo-American Brush Company in fact appearing throughout, and in fact arguing this Appeal, and defending the action, and I shall ask your Lordships to consider very seriously whether you have no power under such circumstances to make an order such as I have asked, and certainly to order them to pay costs.

Mr. Aston: I hope your Lordships will bear in mind 1451
that we make the application now that we might have made to the Court below, if it be necessary, that the third parties be made co-Defendants.

Lord Justice Cotton: I am rather struck by your never having asked to make them Defendants until you succeeded on this appeal. You did not ask for it as regards the Cheesbrough patent.

The Attorney-General: We consented to it, I think.

Lord Justice Cotton: There is no order against 1452
them.

Sir Horace Davey: No, there is no order against them.

Lord Justice Cotton: I have the decree here.

Sir Horace Davey: And I have the decree here.

Mr. Aston: That is very true, and the reason, I can tell your Lordship in a moment. We thought the statement was sufficient.

Lord Justice Cotton: Which statement?

Mr. Aston: "The American Brush Company are

1453 third parties, but I think it will be more convenient, as no question was raised as to that, that they should be put in direct relation with the Plaintiffs." We understood that that was arranged. I do not know that Sir Horace Davey really meant it.

Sir Horace Davey: What is the use of reading an interlocutory observation when you have the order?

Mr. Aston: I am answering your Lordship and explaining why we did not.

Lord Justice Cotton: When was that said?

1454 Mr. Aston: This was at the close of the judgment.

Sir Horace Davey: Nothing was done on it. It was not acted upon.

Mr. Aston: My friend, Sir Horace, ejaculates that it was not acted upon. We thought it was acted upon. We considered that under those circumstances by arrangement there would be no objection to the Brush Company standing in the shoes of Holland—that is what we thought, but, perhaps, we were wrong, and I tell Lord Justice Cotton the reason why the formal ap-
1455 plication was not made on that occasion is that we were, it appears, under a misapprehension. I ask, first, have your Lorships power to so amend the proceedings as to put us in the position in which we should have been had we made that application? "Cropper v. Smith" is clearly in my favour that your Lordships have ample power. Your Lordships could then have directed particulars of objections to have been lodged *nunc pro tunc*, and so have amended the proceedings. In "MacAllister v. Bishop of Roches-
1456 ter" (5 Common Pleas Division, 207), which the Attorney-General is good enough to put into my hands, Lord Justice Lindley says this, "The object of the notice served under Order 16, Rule 18, on the Ecclesiastical Commissioners was that in the event of the Plaintiffs succeeding against the Defendants in the action, the Defendants might be in a position to call upon the Ecclesiastical Commissioners to restore to them the endowment paid for the benefit of the chapel. It is obviously of some importance to the Defendants that the right of the Plaintiff should be decided in the pres-

ence of the Ecclesiastical Commissioners; they have 1457
obtained the advantage in this sense, viz., that the land has been conveyed to them under the Church Building Act, and they hold as trustees for somebody or other. The Ecclesiastical Commissioners having been served with the notice, may take one of two courses—they may disregard it, in which case they will be bound as between the Plaintiff and Defendants in that action but they have taken the other alternative pointed out in Rule 20 of Order 16, which provides that "If a person not a party to the action, who is served as men- 1458
tioned in Rule 18, desires to dispute the Plaintiff's claim in the action as against the Defendant on whose behalf the notice has been given, he must enter an appearance in the action within eight days from the service of the notice." The Ecclesiastical Commisioners have done so. What was their object? Evidently to dispute the Plaintiff's claim in the action as against the other Defendants. Under these circumstances one would suppose that they had elected to make themselves parties litigating, not only with the Defendants 1459
but with the Plaintiff, their object being to defeat the Plaintiff, and thereby, of course, put an end to all questions as to the endowment. They elect to take up that position. They appear for that, and no other purpose. Then, by Rule 21, "If a person, not a party to the action served under these rules, appears pursuant to the notice, the party giving the notice may apply to the Court or a Judge for directions as to the mode of hearing the question in the action determined; and the Court or Judge, upon the hearing of such application, 1460
may, if it shall appear desirable so to do, give the person so served liberty to defend the action upon such terms as shall seem just, and may direct such pleadings to be delivered on such amendments in any pleadings to be made"—this was the part relied upon in "Cropper vs. Smith"—and generally may direct such proceedings to be taken, and give such directions as to the Court or a Judge shall appear proper for having the question most conveniently determined, and as to the mode and extent in or to which the person so served

1461 shall be bound or made liable by the decision of the question." That is the decision of the main question. Now, I submit to your Lordships that you have the power, and on further occasions I have heard your Lordships state that with reference to all control over formal proceedings, so as to put the proceedings in the position in which they ought to have been in order to enable the Court of First Instance to give the judgment which your Lordships on appeal think ought to be given, that your Lordships will direct those proceed-
1462 ings to be taken and those amendments to be made. "Under that rule an order is made on hearing counsel for the Plaintiff, the Defendant and the Ecclesiastical Commissioners, that the latter be at liberty to defend the action as therein stated. The result is that now the action is so constituted that it is competent to Ecclesiastical Commissioners to defend this action as against the Plaintiff, and so protect themselves against any cross-claim by the Defendants, and, therefore, it appears to me that they have a right to obtain discovery
1463 from the plaintiff, and that the Plaintiff has a similar right against them."

LORD JUSTICE LINDLEY: That was discussed a great deal in a mining case.

THE ATTORNEY-GENERAL: I have only this moment had my attention called to it, and if this judgment be right, I should submit to your Lordships that where a third party has appeared, both Lord Justice Cotton and Lord Justice Lindley said if the third party does appear, he does become a Defendant.

1464 LORD JUSTICE COTTON: He becomes an "opposite party," that is the term of the rule.

THE ATTORNEY-GENERAL: I am only saying what I understand this judgment to be.

LORD JUSTICE COTTON: I think you will see that the question turns on the words of the rule which talked of "opposite parties," and they were opposite parties, because they had put themselves in the position of opposite parties to the plaintiff.

THE ATTORNEY-GENERAL: I quite agree with Mr. Aston that I should, if it were necessary, ask your Lord-

ships to amend, but if your Lordships would kindly 1465
look at page 293 of 35, Chancery Division—I do not want to read it if your Lordships have it in your mind —Lord Justice Lopes is good enough to hand this case to me.

LORD JUSTICE LOPES: There is another one in the 34th Chancery Division, which I have handed to Lord Justice Cotton, much to the same effect.

THE ATTORNEY-GENERAL: I think the expression of opinion goes far enough to support my view. If your Lordships have got page 292, I will read the passage 1466
I mean: "It was ordered that notwithstanding the order of the 30th June, 1884, the question of indemnity as between the Ecclesiastical Commissioners and the Defendants be tried after the trial of this action."—that is to say, the Ecclesiastical Commissioners were the third parties—"That was the question to determine, which the Ecclesiastical Commissioners were brought in as third parties, to decide the question of the claim to indemnity as between themselves and the original Defendants, and pursuant to Order 16, Rule 53, the Ecclesias- 1467
tical Commissioners, as such third parties, are to be at liberty to appear at the trial of this action and to oppose the plaintiff's claim so far as they may be affected thereby, and for that purpose to put in oral and documentary evidence." So far it is parallel to the power given to the Brush Company here. "So that they were to try the question in respect of which they were brought in as third parties, namely, the question of indemnity" (that is as between the Defendants and the Ecclesiastical Commissioners) "after the trial of the 1468
action; but the Order puts them in this position, that before that question of indemnity arose at all, they were to come in, and at the trial of the action to contest with the Plaintiff the right which he claims as against the original Defendants." This is exactly parallel to the validity of the patent, and infringement. "They were entitled for the purpose of litigating the question raised by the Plaintiff in his action to appear at the trial, and to contest that with him, and to attend the proceedings in the

1469 action, where the Plaintiff, as against the Defendants, was seeking to obtain judgment. It is very true that the Plaintiff would not as against the Commissioners be able to get any judgment, but they were entitled to go in and attend the trial of the action, and, if they could, to defeat the very foundation of his claim. In my opinion they come within the definition of 'defendant' which we find the 100th section of the Judicature Act; because it says 'the defendant shall include every person served with any writ of summons or process, or
1470 served with notice of, or entitled to attend any proceeding.' They were put in the position of being entitled to attend, as opponents of the Plaintiff at the trial of the action, that is to say, to take part in the proceedings just as if they were Defendants, but with this qualification—that they could not be made directly answerable to the Plaintiff in the action." That, of course, may be said to be, in one view, against me. "And, in my opinion, that carries with it the right to take any such proceedings previously to the trial of
1471 the action which a person made a Defendant by the liberty to attend proceedings, might take, including also the right under Rule 1 of Order 31, to interrogate the Plaintiff." Then Lord Justice Lindley says, at page 296, "Everything now turns on what has been done since; and it appears to me, I confess, that Mr. Justice Kay has failed to give effect to the order of the 17th of March, 1885, which says that the Ecclesiastical Commissioners, as such third parties, are to be at liberty to appear at the trial of the action and to oppose the Plain-
1472 tiff's claim so far as they may be affected thereby, and for that purpose to put in oral and documentary evidence, and to cross-examine the Plaintiff's witnesses. What does that mean except this? That practically they are in the position of Defendants for the purposes of this litigation, up to the trial at all events. Now, it was upon that footing, because they were Defendants within the true meaning of the 100th Section of the Judicature Act, that it was held by this Court that the Plaintiff had a right to interrogate them. It is very true the former case was a little easier than this, be-

it was obvious that in the former case the Ecclesiasti- 1473
cal Commissioners were opposite parties within the words even of Order 31, Rule 1, which relates to discovery and inspection. That was the case your Lordship referred to, namely, where the words were "opposite parties" in the Ecclesiastical case. "But when you look to see what is meant by 'opposite parties,' I do not think it means more than the Plaintiff or the Defendant, the Defendant, if the Plaintiff is applying for inspection, and the Plaintiff if the Defendant is applying for inspection. I cannot 1474
see who is an opposite party within the meaning of the rule, if he is not either a Plaintiff or Defendant within the interpretation clause, Section 100 of the Judicature Act, I do not think that it is possible to find such a person. Accordingly we find when we look into the judgment of the Court, which is reported in 34 Chancery Divi ion, 223, that the Lords Justices treated the Ecclesiastical Commissioners as defendants as well as opposite parties. Being Defendants, not because they are third parties, but by 1475
reason of the order of the 17th March, 1885, they are entitled to leave to deliver interrogatories, what kind of interrogatories we have not to consider." With regard to the point, my friend opened about the form of the order; he was kind enough to hand me a copy, and I now have the original. I humbly submit to your Lordships, that having regard to what passed in Court, the arrangement has been carried out, and the parties have been put into direct relation, because I find the following inquiry is to be made: "Enquiry of the 1476
damages the Plaintiffs have sustained by reason or in consequence of the manufacture, sale, supply, letting on hire, or user of any such incandescent electric lamps so manufactured, sold, let on hire, or used by the Defendants respectively, or either of them, or by any person or persons to their order or for their use." Then there is an order as to the payment of damages.

SIR HORACE DAVEY: Payment of damages by the Defendants, Holland and the Jablochkoff Company.

THE ATTORNEY-GENERAL: Certainly, I quite admit

1477 that. Although it may be said we ought to have been a little more careful as to the actual language used, I submit to your Lordships, your Lordships can make the order certainly as regards payment of costs, for which I have asked more than once.

LORD JUSTICE COTTON: Do you ask us to amend?

THE ATTORNEY-GENERAL: Yes, I ask your Lordships to amend if necessary.

LORD JUSTICE COTTON: What do you say as regards the application for liberty to amend, Sir Horace
1478 Davey?

SIR HORACE DAVEY: Liberty to amend after judgment? Not only after judgment in the Court below, but after judgment in the Court of Appeal they ask for liberty to amend. I do not know what defence the Anglo-American Brush Company might have had. My learned friend has hinted at one reason why they did not make the Anglo-American Brush Company Defendants; but if they deliberately choose to sue Holland, who used the lamps, instead of suing
1479 the persons, who, it is alleged, made and furnished the lamps, in which the questions might be fairly tried between them, I venture to submit it would be contrary to all precedent to allow them to amend by making the Anglo-American Brush Company Defendants for the purpose of obtaining relief against them, and putting them in the positition of Defendants when, for excellent reasons, I have no doubt, they did not sue the Anglo-American Brush Company in the first instance. My learned friend, the Attorney-General, was good enough to say
1480 he might have had my assistance, I do not quite know—I should rather have put it the other way, that I might have had the advantage of being led by my learned friend; but I should not have alluded to that if the Attorney-General had not.

THE ATTORNEY-GENERAL: That was the only thing I could think of.

SIR HORACE DAVEY: And the only thing I could think of.

LORD JUSTICE COTTON: I suppose you both have general retainers?

SIR HORACE DAVEY: I am not going to tell the se- 1481
crets of the profession. There were, I have no doubt, excellent reasons, and the very discreet and able solicitors and counsel who conducted the litigation on behalf of the Edison Company knew exactly what they were about. If they chose to select as Defendant a person like Holland, who used the lamps at his Exhibition, then I venture to say it would be contrary to all precedent and contrary to all principles for them, after they have got judgment and not before (for they did not ask for it before Mr. Justice Kay), to turn round 1482
and say, "Now, having got judgment, we will place you in the position of Defendants and ask for substantial relief against you." I do not know—I am entitled to say I do not know—what defence the Anglo-American Brush Company might or might not have had.

LORD JUSTICE COTTON: I do not think we need hear you further on the question of amendment. Do you object to an order being made against you for costs? I do not think it will hurt you much.

SIR HORACE DAVEY: As a matter of fact my clients 1483
do not care, but if your Lordships ask me whether as a matter of form it would be right, in my submission it would not.

LORD JUSTICE COTTON: It seems to have been done in some cases.

SIR HORACE DAVEY: Yes, but your Lordship sees that every different directions were given as to the third party. He was allowed to put in a defence and counterclaim.

THE ATTORNEY-GENERAL: Not in all cases; only in 1484
one.

SIR HORACE DAVEY: Quite so; he put in defence and counterclaim; he was the actual Defendant in the action.

LORD JUSTICE LINDLEY: The Brush Company have put in no pleadings.

SIR HORACE DAVEY: No, my Lord, no pleadings; all they did was to appear at the trial.

LORD JUSTICE LINDLEY: They appeared in Court. The action was fought through the other people.

1485 SIR HORACE DAVEY: Certainly. I will be perfectly frank. The solicitors were changed, and the solicitors of the Brush Company became the solicitors on the Record for Holland and the Jablochkoff Company. My Lord, I do not care to contest the order for costs, because it will come through the solicitors, and the solicitors are exactly the same, and it really is a matter of no importance at all, unless it be used against me as a matter of principle as a concession.

LORD JUSTICE COTTON: What was the order in the
1486 judgment under appeal with regard to costs?

SIR HORACE DAVEY: That they be paid by the defendants.

THE ATTORNEY-GENERAL: No, the plaintiffs.

LORD JUSTICE COTTON: On this part, but on the Cheesbrough?

THE ATTORNEY-GENERAL: There is a decision in favour of the Plaintiffs with regard to the Cheesbrough patents.

SIR HORACE DAVEY: The order is this: It is referred
1487 to the Taxing Master to tax the costs of the Plaintiffs so far as the same relates to the Cheesbrough patent on the higher scale, and it is referred to the Taxing Master to tax the costs of the Defendants Holland and the Jablochkoff and General Electricity Company, Limited, of this action, that is, the Defendants, naming them. We did not get our costs in the Court below of the Edison patent.

THE ATTORNEY-GENERAL: There were no extra costs.

SIR HORACE DAVEY: That may be. I do not know
1488 whether there were any extra costs. There are costs of appearing in Chambers on summonses, and so forth.

THE ATTORNEY-GENERAL: They were ordered to be costs in the case.

SIR HORACE DAVEY: We did not get them. "So far as the same relate to the Edison patent, and the Taxing Master is to set off the costs of the Plaintiff and Defendant when taxed and certify the balance, and the balance is to be paid by whichever is found liable, and it is ordered that such balance be paid to the party to whom the same shall be certified to be due." I am sure

I forget what I said, or why I said it, or what was in my 1489
mind, but on this it is perfectly clear that the decree of the Court below is simply a decree between the parties to the action, and I conceive in the existing state of things no other decree could have been made. The decree properly draws the distinction, in its very commencement, between the Defendant and the Anglo-American Brush Company, third parties. My learned friend says they appeared, and they had a right to appear, under the order. They appeared
for the purpose of seeing that the defence, upon 1490
the result of which their indemnity depended, was properly conducted by the Defendants themselves. I appeared—my brief I see is endorsed for the Defendant and for the third parties, and I appeared for both with my learned friend, and on the appeal my brief is endorsed for the Respondents. I have not got the Notice of Appeal.

THE ATTORNEY-GENERAL: It was addressed to the third parties.

SIR HORACE DAVEY: I suppose it was addressed to 1491
all.

LORD JUSTICE COTTON: The Notice of Appeal was addressed to the Defendants and the third parties.

SIR HORACE DAVEY: I appear for the Respondents generally. When they succeeded in the Court below on the Cheesbrough patent they took an order in what I conceive to be the proper form.

LORD JUSTICE COTTON: There may be a distinction as regards the cost of the Appeal, as you appear here as
Respondents and oppose the Appeal, and as they are 1492
successful, whether you ought not to pay those costs

SIR HORACE DAVEY: I do not think the question of costs worth discussing, because we intend to pay the costs, even if my learned friend's suggestion as to insolvency is correct.

THE ATTORNEY-GENERAL: I did not suggest insolvency. I said I was not satisfied the others were sufficient.

SIR HORACE DAVEY: Then as to the insufficiency, I will say, of Holland and the Jablochkoff Company, I

1493 apprehend the Court would not allow the Plaintiffs to be defeated, and at any rate they will not be defeated in that way. As regards the question of costs, I do not care to discuss the question, but I do submit, as regards relief, it is the first time I ever heard, still less by the Attorney-General of England, a suggestion that a relief could be had against the party who was not the Defendant in the action.

THE ATTORNEY-GENERAL: I have only one word to say on this matter of costs.

1494 LORD JUSTICE COTTON: Does Mr. Graham wish to add anything?

MR. GRAHAM: No, my Lord.

THE ATTORNEY-GENERAL: I said not one word about solvency or insolvency. What I said was this, that we might be entitled to have relief for our costs, which were a very large amount, against the third parties, and so I wish to have the order which we were entitled to. I find it is not the fact that the order for costs has only been made in cases
1495 in which the third party put in a defence. In "Hornby vs. Cardwell" the third party was simply a third party allowed to attend the trial; but I submit to your Lordships whatever it be, Order 54 says the Court may order any one or more to pay the costs of any other or give such directions as to costs as the justice of the case may require.

Now, my Lords, Sir Horace has admitted that immediately after the Defendants appeared the solicitor was changed, the solicitor for the Anglo-American Brush
1496 Company conducted the whole litigation; the Anglo-American Brush Company are the only persons who called the witnesses and who fought the action: they appeared at the trial, they appeared on the proceedings on the Appeal, they are said to be in the Court below, on the very opening of the proceedings, the practical Defendants, and I ask your Lordships, not as a matter of concession by my learned friend, but as a matter of right, to order that the costs of this litigation be paid by the Anglo-American Brush Company.

LORD JUSTICE COTTON: Assuming that we have power

to direct all the costs, not only the costs of the Appeal, 1497
to be paid by the third party, how can we make that consistent with the judgment which you have got as regards the Cheesbrough patent?

THE ATTORNEY-GENERAL: Because persons did not ask for what they are entitled to, or the extreme of what they are entitled to, and the order was evidently drawn up without any discussion. We have not bargained away our rights. We are before your Lordships now to obtain the judgment which the Court might have given. It was really two actions rolled into one, an 1498
action in respect of the infringement of two letters patent, and there would be no inconsistency at all. Your Lordships find that the great fight in respect of the Edison patent was conducted throughout by the Anglo-American Brush Company. Your Lordships know the adjournment that took place for the carrying out of the expensive experiments which were directed to the subject of Professor Stokes' report, all done at the instance of the Anglo-American Brush Company. It might be that it was a comparatively speaking small 1499
matter, but the Plaintiffs have not in any way divested themselves of their rights by taking the order in respect of the Cheesbrough patent in the terms in which they did. We have not in any way altered the position of the Defendants; we have, as a matter of fact, got an order against one Defendant for one set of costs; but, my Lords, having regard to the nature of the litigation, we ask your Lordships to say that the justice of the case, if it be inquired into at all, require that the costs should be paid by the real Defendants. Those real 1500
Defendants are the Anglo-American Brush Company, and I ask your Lordships to make an order under Rule 54. I am not entitled to say anything on the other point, because your Lordships stopped Sir Horace Davey upon it.

LORD JUSTICE COTTON: A point has been raised here which is a curious one, but it arose simply after judgment, and I thought the matter was simply giving the judgment now to apply to both patents, which Mr. Justice Kay had given as regards the one which he

1501 decided in favor of the Plaintiffs. But the Plaintiffs now claim to treat the third parties as if they were Defendants, not only in the way of making them pay costs, but also in the way of granting relief against them—granting an injunction and consequential relief. As regards that, I think it would be wrong, because the third parties are not Defendants. If a Plaintiff has a direct claim against a third party, as soon as that is known the proper course is to amend the Statement of Claim and make him a Defendant, and then the Court
1502 has all that jurisdiction as against the Defendant which it gains by serving that party with a writ, and bringing him in as a party to the action. Why that was not done here I cannot understand except that possibly the Plaintiffs did not like to bring in another person against whom they would be liable to costs, as they did before Mr. Justice Kay as regards this portion of the Edison patent.

One does not wish that there should be unnecessary litigation. I do not see that for that reason one could
1503 assume a power which in my opinion we have not got. It is very true that when this third party came in and desired to defend the action, and the direction was given, he might have had that liberty given on his undertaking to submit to any judgment which the Court might think fit to give as against him, supporting the interest of the Defendant, and really being the person who ought to have been made Defendant. But that was not done. The order which was made was simply an order in these terms, that he should be at liberty to
1504 appear at the trial of the action, and take such part therein as the Judge shall direct, and the said Anglo-American Brush Electric Light Corporation, Limited, shall be bound by the decision of the Court in this action in any question as to the above indemnity which may arise between that Company and the Defendants. If the Plaintiffs were not satisfied with that they ought to have said " No, that will not do for us, other terms ought to be imposed upon this third party;" but the proper course looking now still to the origin of the jurisdiction, and that which brings a person within the

jurisdiction of the Court, ought to have been for the 1505
Plaintiff to amend his appeal and say: " Here are the real persons who are disputing or infringing this patent, and who are making these things which I say are infringements of the patents." That course was not taken for some reason; I do not know why. In my opinion we have no jurisdiction to make a decree against this third party as if he were a Defendant, and to grant an injunction against him, and grant damages against him in this action as if he were made a party. Whether he will be unwise enough to dispute the 1506
Plaintiff's rights as regards this patent when another action is brought against him I cannot suppose. But then the Attorney-General says, Give me leave to amend, and Mr. Aston says that we ought to make such order as the Court ought to have made below, and to make such amendments as may be necessary for that purpose. But what was the course taken by the Plaintiffs on the trial in the Court below. In the Court below they never asked for this relief as against this third party. It is very true 1507
there was an expression by Sir Horace Davey, which was relied upon, that the third party sought to be put in direct relation to the Plaintiff. I do not quite understand myself what that meant. It is not as clear as Sir Horace Davey's expressions usually are, but these parties did not act on that and treat it as a statement that the third party should be made a Defendant. It may have been immaterial then, because the costs given to the Defendant were the costs of the Defendant as regards that part of the action in which the Plaintiff 1508
failed, and costs were given as against the Defendant as regards that part of the action on which the Plaintiff succeeded. In my opinion it would be wrong under those circumstances, and in the course which has been adopted by the plaintiffs now, to grant liberty to amend to enable the Court to give different relief against the third party than that which was asked for at the trial of the action.

Now, as to the costs. As regards the costs of the Appeal, as the third parties do appear on the Appeal, and

1509 as they were served with Notice of Appeal, there will
be no difficulty in making an order against them for
payment of the costs of the Appeal, and, in my opin-
ion, the Court has jurisdiction, having regard to Rule
54, to make them pay the costs. Therefore, as regards
this part of the action, I think it would be wrong to
alter the judgment. As regards the other part of the
action we may, when we alter the judgment of Mr. Jus-
tice KAY, make an order against the third party as well
as against the Defendants for payment of the costs of
1510 the action.

LORD JUSTICE LINDLEY: In substance the third par-
ties here are the people who fought the Plaintiffs, and
if I had tried the case and come to the same conclusion
I have done on the merits, and had been asked to
amend by making the third parties Defendants, I
should have done it without the slightest hesitation,
and I am not at all sure, if I were sitting alone on the
Appeal, I should not do it now. I think there is power
to do it, but I will not differ from my learned brother
5111 on that point. There is a little doubt as to whether it
ought to be done, and so let in the very wide terms of
Order 28, Rule 1. When you see, at least apparently,
that no conceivable injustice can be done—there are no
merits in it, it is a mere matter of form—I should get
over it. However, as I say, there has been no amend-
ment. As to costs there is no difficulty at all. Rule
54 of Order 16 clearly gives power to make what order
we think right as to costs. Now, what order is right?
Those who really fought the Plaintiffs and failed should
1512 pay the costs. The order will be that the third party
do pay the costs here and below.

THE ATTORNEY-GENERAL: I have to ask your Lord-
ships for the costs of the shorthand notes. Your Lord-
ships will remember they were used in this Court, and
I think I may say the case could not have been con-
ducted without them.

LORD JUSTICE COTTON: Of the evidence? I am
afraid we cannot do that.

LORD JUSTICE LINDLEY: We had the Judge's notes.

THE ATTORNEY-GENERAL: I am told I need not ask

your Lordships; it is agreed. I have to ask your Lord- 1513
ships for costs on the higher scale. Your Lordship is
aware that is governed entirely, by the nature of the
action, and it has been allowed by your Lordship's
Court in several patent actions of this difficulty, and
I may say in several not of this difficulty and com-
plexity.

LORD JUSTICE COTTON: What happened in the Court
below? Because in the Court below, where the
scientific witnesses attend, they are paid considerable
sums. In the Court of Appeal that is not necessary. 1514

THE ATTORNEY-GENERAL: Mr. Justice Kay gave it
us in the Cheesbrough part of the action.

LORD JUSTICE COTTON: I was only referring to the
Court of Appeal.

THE ATTORNEY-GENERAL: I did not make my mean-
ing clear to your Lordships. The Court of Appeal have
certainly allowed it, or have not differed from it to my
knowledge in two or three cases, but I was pointing out
to your Lordships that Mr. Justice Kay allowed it in
respect of the Cheesbrough part of the action, which 1515
certainly was nothing like as complicated as this, and
he gave it to them on the Edison part of the ac-
tion.

LORD JUSTICE COTTON: Yes, in the Court below cer-
tainly we ought to.

THE ATTORNEY-GENERAL: As Mr. Justice Kay gave
the Defendants their costs on the higher scale on that
part of the action in which they succeeded, I think, my
Lords, I am entitled to them.

LORD JUSTICE COTTON: I was only referring to the 1516
costs of Appeal.

THE ATTORNEY-GENERAL: I do not think that affects
it. I think it only affects the cost of the trial. If it
did I think your Lordship would agree that it was a
case in which the rule ought to apply.

LORD JUSTICE COTTON: I think in some cases which
come before the Court of Appeal it is based on this:
that where costs were allowed on the higher scale it
was because the case required the attendance of wit-
nesses, who are very expensive, and they come.

1517 THE ATTORNEY-GENERAL: Your Lordship made an order in a patent action which I was in two or three years ago.

LORD JUSTICE COTTON: In the Court of Appeal?

THE ATTORNEY-GENERAL: Yes, my Lord; I cannot remember the name at the moment, but I can find it.

MR. ASTON: It is a case where the Attorney-General succeeded against me.

THE ATTORNEY-GENERAL: I apprehend your Lordships would think that if Mr. Justice Kay thought it a
1518 proper case for costs against us on the higher scale, it is a proper case in our favour.

LORD JUSTICE COTTON: Oh, yes; in the Court below on the trial of the action.

SIR HORACE DAVEY: I do not think it makes any difference in the Court of Appeal.

THE ATTORNEY-GENERAL: May I read my endorsement? I understand this to be the order, "The judgment of Mr. Justice Kay reversed, and the Appeal allowed."

1519 SIR HORACE DAVEY: Reversed so far as regards the Edison patent.

THE ATTORNEY-GENERAL: And the Appeal allowed with costs, with certificates that the Plaintiffs have proved their breaches.

SIR HORACE DAVEY: I suppose you desire judgment in the same terms as in the Cheesbrough patent for inquiries?

THE ATTORNEY-GENERAL: Yes, certainly. Then the only other thing I have to ask for is a certificate that
1520 the Plaintiffs have proved their breaches, and that the validity of the patent came in question.

SIR HORACE DAVEY: I have put "usual certificates to be given."

THE ATTORNEY-GENERAL: Order against the third parties for payment of the costs of the action so far as relates to this part of the action, and costs of the Appeal.

LORD JUSTICE COTTON: Yes.

THE ATTORNEY-GENERAL: And costs on the higher scale.

LORD JUSTICE LINDLEY: In the Court below? 1521

THE ATTORNEY-GENERAL: In the Court below.

LORD JUSTICE LINDLEY: We have once certified about the validity of the patent.

THE ATTORNEY-GENERAL: Oh, yes; more than once; where your Lordships reverse it you give the same certificate.

LORD JUSTICE LINDLEY: In this particular patent you have got the certificates already; you do not want another.

THE ATTORNEY-GENERAL: I do not know that we do, 1522
but there is no reason why we should not have it.

LORD JUSTICE LINDLEY: I do not know. If you have it you do not want another.

LORD JUSTICE COTTON: If you do not want it for any useful purpose it will throw a doubt on the sufficiency of the prior certificate.

THE ATTORNEY-GENERAL: I do not think it is necessary.

LORD JUSTICE COTTON: There will be a little alteration required in the judgment. The substance is, re- 1523
verse that portion which dismissed your action as regards the Edison patent, and then there will be a little variation, because a similar affidavit will be required as to the lamps made according to this patent. Then the injunction will refer to both, and there will be damages in regard both to this patent and the Cheesbrough.

MR. ASTON: We do get the certificate that we have proved our breaches.

LORD JUSTICE COTTON: Yes; that must be in each
action. 1524

1525 CIRCUIT COURT OF THE UNITED STATES,

FOR THE WESTERN DISTRICT OF PENNSYLVANIA.

THE CONSOLIDATED ELECTRIC LIGHT COMPANY, Complainant,

AGAINST

1526 MCKEESPORT LIGHT CO., Defendant.

No. 5, May Term, 1888.

ON BILL AND FINAL HEARING.

Opinion of the Court.

BRADLEY, Circuit Justice:

This is a bill for the alleged infringement of a patent,
1527 filed December 8, 1887; and the patent alleged to be infringed is dated May 12, 1885, and is for Improvements in Electric Lamps. It was granted upon the application of William E. Sawyer and Albon Man, of New York, to their assignee, the Electro-Dynamic Light Co., and by mesne assignments was transferred to the complainant, whose title commenced in October, 1882, before the patent was issued. The application for the patent was filed January 9, 1880, and the issue was delayed by various proceedings in the Patent
1528 Office, including an interference with an application of Thomas A. Edison, which had been filed a month earlier, to wit: December 11, 1879. Various defenses were set up in the answer, such as anticipation by prior inventions, vagueness of description, want of novelty and utility, undue change of specification after filing, surreptitious claim of an invention made by Edison, &c. It is conceded that the defense of the suit is conducted by Edison Electric Light Company, a corporation of New York, which sells the lamps complained of as infringements of the patent, and is interested as assignee

in the patents for electric lights formerly owned by 1529
"The Edison Electric Light Company," and in the question of interference between Edison and the complainants.

In the specification of the patent sued on, called Sawyer and Man's patent, the invention is described as relating to that class of electric lamps employing an incandescent conductor enclosed in a transparent hermetically sealed vessel or chamber, from which oxygen is excluded, and constituting an improvement upon the apparatus shown in a previous patent granted to the 1530
same parties (Sawyer and Man) June 18, 1878, and numbered 205,144.

It is further stated in the specification that the invention relates more especially to the incandescing conductor, its substance, its form and its combination with the other elements composing the lamp, and that the improvement consists, first, of the combination in a lamp-chamber, composed wholly of glass, as described in the said former patent, of an incandescing conductor of carbon made from a vegetable fibrous material, in 1531
contradistinction to a similar conductor made from mineral or gas carbon, and also in the form of such conductor, combined in lighting circuit within the exhausted chamber of the lamp.

The construction of the lamp is then described, reference being made to the drawings for illustration. The lamp, as described and shown in the drawings, is a glass cylinder with rounded top, cemented at the bottom to a glass disk, or plate, ground to fit closely to the cylinder, and the whole bottom enclosed in a cup filled 1532
with wax or suitable cement, to prevent as far as possible the access of atmospheric air. Two holes are made in the bottom of the lamp, for the passage of the wires which convey the electric current into and out of the lamp. The carbon conductor within the glass cylinder is connected by its extremities to these two wires, respectively, in a mode specified in another patent of Sawyer and Man, dated December 10, 1878, and numbered 210,809, so as to constitute a part of the circuit; and having a low conductivity, and presenting a certain

1533 amount of resistance to the current of electricity, it becomes incandescent and highly luminous. If the carbon, in this condition, were exposed to atmospheric air, that is, to oxygen, it would be consumed by combustion. Hence another part of the combination necessary to the result consists in filling the lamp with nitrogen gas, or other gas, which prevents combustion, to the exclusion of atmospheric air. The mode of doing this is pointed out in the Patent No. 205,144, before referred to.

1534 It is further stated in the specification that in the practice of the invention the applicants had made use of carbonized paper, and also wood carbon. Also, that they had used conductors of different shapes, such as V-shaped, and with rectangular corners, but preferred the arch-shaped, as shown in the drawings. It is added that a description of the mode of making the illuminating carbon conductors described, "and making the subject matter of this improvement," was unnecessary, as they could be made by any one skilled in the art by
1535 the ordinary well-known methods in practice.

The specification then states the proposed practical advantages of the arched form of the conductor, by its permitting the carbon to expand and contract, and casting less shadow; and the advantage of making the wall of the lamp wholly of glass, by its preventing oxidation, leakage, &c.; and states particularly the advantages resulting from the manufacture of the carbon from vegetable fibrous or textile material instead of mineral or gas carbon. "Among them," it says, "may be
1536 mentioned the convenience afforded for cutting and making the conductor in the desired form and size, the purity and equality of the carbon obtained, its susceptibility to tempering, both as to hardness and resistance, and its toughness and durability." "We have used," it is added, "such burners in closed or hermetically sealed transparent chambers, in a vacuum, in nitrogen gas, and in hydrogen gas; but we have obtained the best results in a vacuum, or an attenuated atmosphere of nitrogen gas, the great desideratum being to exclude oxygen, or other gases capable of combining with car-

bon at high temperature, from the incandescing-chamber, as is well understood." 1537

The patent has four claims:

"1. An incandescing conductor for an electric lamp of carbonized fibrous or textile material, and of an arch or horseshoe shape, substantially as hereinbefore set forth.

"2. The combination, substantially as hereinbefore set forth, of an electric circuit and an incandescing conductor, of carbonized fibrous material, included in and forming part of said circuit, and a transparent hermetically-sealed chamber in which the conductor is enclosed. 1538

"3. The incandescing conductor for an electric lamp, formed of carbonized paper, substantially as described.

"4. An incandescing electric lamp consisting of the following elements in combination: first, an illuminating chamber made wholly of glass hermetically sealed, and out of which all carbon-consuming gas has been exhausted or driven: second, an electric-circuit conductor passing through the glass wall of said chamber, 1539 and hermetically sealed therein, as described; third, an illuminating conductor in said circuit, and forming part thereof, within said chamber, consisting of carbon made from fibrous or textile material, having the form of an arch or loop, substantially as described, for the purpose specified."

The great question in this suit is, whether the patent sued on is valid, so far as it involves a general claim for the use, in electric lamps, of incandescing carbon conductors, made of fibrous or textile substances. If it is, 1540 the complainants must prevail. If it is not, the bill must be dismissed.

The claims of the patent (excluding the third claim which the defendants do not use, and which is not involved in the case) may be summarized as follows: (1) A conductor of carbon made of fibrous or textile material, and of an arched form; (2) A conductor of carbon made of fibrous material in a hermetically sealed chamber, without regard to form; (3) The combination of a conductor of carbon, made of fibrous or

1541 textile material in an arched form, and the glass chamber hermetically sealed, and deprived of carbon-consuming gas. The claim of the combination last named may be dismissed from consideration as a separate claim, because a glass chamber, hermetically sealed, for holding the light, has always been used and must necessarily be used in all incandescing carbon electric lamps. It was used by King in 1845, by Greener and Staite in 1846, by Roberts in 1852, by Konn in 1872, by Kosloff in 1875, and by others.
1542 Unless the patent is valid for the conductor of carbon, made of fibrous or textile material in an arched form, it cannot be made valid by combining such conductor with a glass chamber hermetically sealed.

We are equally of opinion that the giving of an arched form to the conductor was not new, and could not give to the claim any validity which it would not have as a broad claim of the conductor itself, made of carbon produced from a fibrous material. The arched or bent shape in incandescent conductors was applied
1543 in 1848 by Staite to an iridium conductor, in 1858 by Gardiner and Blossom to a platinum conductor, and in 1872 by Konn to a carbon conductor. In the last case the conductor was enclosed (as it had to be) in a glass lamp or case filled with nitrogen or other gas incapable of supporting combustion. The carbon, it is true, is presented in a V-shaped form, but in a similar patent, applied for a few weeks afterwards, claiming the same apparatus for the production of heat, the patentee very properly says, "It is evident that stems of other
1544 shapes may be used."

If the U or V-shaped form had not been given to carbons made of fibrous material, for incandescent light, before Sawyer and Man adopted that form, it was merely an application by them of an old device to a new and analogous use. But the carbons used by Konn included charcoal as well as other carbons. He mentions graphite as preferable; but he claims the use of carbon generally.

As before stated, therefore, the patent must be construed as making the broad claim to the use, in electric

incandescing lamps, of all carbons made of fibrous or 1545
textile substances. Is the patent valid for such a broad claim? The defendants contend that it is not: first, because no such invention was set forth in the original application, but was introduced for the first time more than four years after it was filed, and after the same material had been used by Edison, and claimed by him in an application for a patent; secondly, because Edison and not Sawyer and Man, was really the original and first inventor of an incandescent conductor made of
fibrous or textile material for an electric lamp; thirdly, 1546
because if Edison was not the first inventor, the thing claimed as an invention was old, and neither of the parties was entitled to a patent for it.

The whole vegetable kingdom is composed of fibrous material and all carbon or charcoal made therefrom comes within the scope of the complainant's claim. Silk is fibrous or textile, and carbon made from silk thread is, therefore, within the claim. Mineral coals, and the carbon produced in gas retorts are not included.
Can it possibly be said when we look at the history of 1547
the art of electric lighting, that carbon made from fibrous or textile material was never used for that purpose until Sawyer and Man used it in 1878? We think not. We do not propose to describe in detail the various English patents of prior date, which have been adduced in evidence. The word charcoal as well as carbon is constantly used to define the material from which the conductors were made; and that word, in the English language, *prima facie* refers to carbon
or coal made of wood. We cannot yield our assent to the 1548
ingenious theory of the complainant's counsel and some of their witnesses, that the word has come to have an artificial or technical meaning in this particular art, signifying gas or mineral carbon. We think that carbon made from wood or other vegetable material is generally intended. In King's patent of 1845, he says, "the nature of the invention consists in the application of continuous metallic and carbon conductors, intensely heated by the passage of a current of electricity to the purpose of illumination" * * * "when carbon

1549 is used, it becomes necessary on account of the affinity this substance has for oxygen at high temperature, to exclude from it air and moisture. To accomplish this in the most perfect manner, it should be enclosed in a Torricellian vacuum." He does not confine himself to any particular kind of carbon. It is true he does afterwards say "that form of carbon found on the interior of coal gas retorts which have long been used, is well suited for this purpose;" but his claim is general for "the application of metallic and carbon conductors in-
1550 tensely heated, &c," and the use of wood carbon would have infringed the patent. Greener and Staite, in their patent of 1846, in describing how they prepared the carbon for the incandescing stems in their lamps, say: "We take a quantity of lamp-black or of charcoal reduced to powder, or of coke also reduced to powder, which has been purified, &c. The carbon thus highly purified we next bring into a state of great dryness and then convert it into solid prisms, or into cylinders both solid and hollow, &c." The charcoal here re-
1551 ferred to is clearly wood charcoal. Roberts in his patent of 1852, says: "Another part of my invention consists of a mode of obtaining electric light by passing a current of electricity through a thin piece of graphite, coke or charcoal, or other infusible body, being a conductor of electricity, whilst it is enclosed in a vacuum or space not containing any oxygen or other matter which can cause the combustion or destruction of it when brought into an incandescent state by the action of the current of electricity." This certainly refers to
1552 wood charcoal. We have already alluded to Konn's patent of 1872, in which he claims carbon stems generally, arranged as specified in the patent, for giving incandescent light. We may add that in the earliest experiments of Sir Humphrey Davy and others, on the effects of the electric current in producing light in various substances, charcoal was one of the most frequent articles used for that purpose. Long prior to 1878, it was a well known fact in science and the arts, that the transmission of the electric current through a pencil of charcoal interposed in a metallic circuit would produce intense light;

and that when this charcoal was guarded from contact 1553
with oxygen, in a vacuum or otherwise, it would not be consumed. This is fully verified not only in scientific writings, but by the statements found in several of the patents referred to. The great desideratum was to construct an apparatus and to discover a process which would make the light economical and convenient, of use for ordinary domestic purposes. We are clearly of opinion therefore, that neither Sawyer and Man, nor Edison can maintain any just claim to the exclusive use of charcoal generally in any form, as an incandescing conductor 1554
in an electric lamp. This view of the subject is sufficient to decide the present case against the complainants. But there are other considerations which go to corroborate the conclusion to which we have come; which, however, we shall only cursorily examine.

It is very clear to us that in the original application for the patent sued on, the applicants had no such object in view as that of claiming all carbon made from fibrous and textile substances as a conductor for an incandescing electric lamp. Nothing on which to base 1555
any such claim is disclosed in the original application. We have carefully compared it with the amended application on which the patent was issued, and are fully satisfied that after Edison's inventions on this subject had been published to the world, there was an entire change of base on the part of Sawyer and Man, and that the application was amended to give it an entirely different direction and purpose from what it had in its original form. It is true that the last claim of the original was for "an illuminating arc made of carbon- 1556
ized fibrous or textile material." But this claim had special reference to the arched form of the conductor rather than to the material of which it was composed. And this claim is the only expression in the application which even suggests any exclusive right to all vegetable carbons, or any invention or discovery in relation thereto. No advantage in the use of said carbon is anywhere alleged. The whole scope and purpose of the application related to the arched form of the conductor. A subsidiary purpose was to claim

1557 carbon made from paper or pasteboard. They say distinctly, "Our improvement consists in the employment of an incandescent arc of carbon in the circuit as the light giving medium;" "carbon" generally, not any particular carbon. By an adroit amendment made in 1885, they say: "our improvement relates more especially to the incandescing conductor, *its substance*, its form, and its combination with the other elements composing the lamp." The purpose of this amendment is obvious, and needs no comment. After explain-
1558 ing the drawings, the original application goes on to say: "Our improved burner or incandescent arc, consists of an arch-shaped or semi-cylindrical piece of carbon A, mounted in its clamps or supports in the usual well known ways. We have tried carbonized paper covered with powdered plumbago, wood carbon or charcoal, and ordinary gas carbon. We have also used such arcs or burners of various shapes, such as pieces with their lower ends secured to their respective supports, and with their upper ends united so as to form
1559 an inverted V-shaped burner. We have also used arcs of varying contours, that is, with rectangular bends instead of curvilinear ones, but prefer the arched shaped, as the shadow cast by such a burner is less than that produced by other forms of burners. We have used such burners in close transparent chambers, in a vacuum, in nitrogen gas and in hydrogen gas, but have attained the best results in a vacuum or attenuated atmosphere of nitrogen, the great desideratum being to exclude oxygen from the combustion chamber
1560 as is well understood. The operation of our improved apparatus will readily be understood from the foregoing description." Then come the claims as follows: "First. Incandescing arcs for electric lights, made of carbon, substantially as hereinbefore set forth. Second. Incandescing arcs of carbon in combination with the circuit of an electric light. Third. The combination substantially as hereinbefore set forth, of the circuit of an electric light, an incandescing arc of carbonized paper included in the circuit, and a close transparent chamber in which the arc is enclosed. Fourth. An in-

candescing arc made of carbonized fibrous or textile 1561
material."

This is the whole of the original application, except the formal introduction. The arc is everything. The changes are rung on the arc. The fact is, that Sawyer and Man were unconscious that the arc was not new, and supposed that they could get a patent for it; but as their eyes were opened, they changed about and amended their application, and made the material of the conductor the great object—carbon made from fibrous or textile material. Compare the original with 1562
the amended application, as first stated in this opinion, and this purpose most obviously appears. The carbons mentioned in the original application are merely mentioned by the way, to show that the arched form would apply to all kinds of carbon. "We have tried carbonized paper, covered with powdered plumbago, wood carbon, and ordinary gas carbon." This is changed in the amended application, to the words: "in the practice of our invention we have made use of carbonized paper, and also wood 1563
carbon." The object of this change is manifest. In other parts of the amended specification, the importance of vegetable carbon as distinguished from gas carbon is dwelt upon. Thus, they say in a former paragraph: "Our improvement consists, first, of the combination in a lamp chamber, composed wholly of glass, and described in Patent No. 205,144, of an incandescing conductor of carbon, made from a vegetable fibrous material, in contradistinction to a similar conductor made from mineral or gas carbon, and also in the form of 1564
such conductors, so made from such vegetable carbon, and combined in the lighting circuit within the exhausted chamber of the lamp."

The fact that the whole object of the application was changed is evinced by the correspondence of the parties. In a letter from Wm. D. Baldwin, one of the attorneys of the applicants for the patent, to his clients The Electro-Dynamic Light Co. (who then owned the interest in the invention), dated Jan. 8, 1880, he says, "I have this day prepared an

1565 application for patent of arched form of incandescent carbon electric lamp, made by Wm. E. Sawyer and Albon Man, as joint inventors, containing a request for the issuing of such patent to your company, &c.— I will not make any alteration in the claims or specification of said patent, enlarging its scope beyond its intended purpose of covering the arched or angular form of the carbon used for incandescent electric lights."

In a letter from Albon Man, one of the applicants for the patent, to a Mr. Cheever, dated December 12th,
1566 1880, he says: "I have received your two notes of 11th inst. enclosing letter from the Patent Office, advising Messrs. Baldwin, Hopkins and Payton, of substitution of Mr. Broadnax, as attorney in *carbon arch matter.*" This had relation to the application in question, Baldwin, Hopkins and Payton being the solicitors in the case, and Mr. Broadnax being substituted in their place. "Carbon arch matter" are words that could hardly be more suggestive.

As before stated, Edison had filed an application for
1567 a patent in December, 1879, about a month prior to the application in question, and in September, 1880, an interference was declared between the two applications. The controversy raised on this interference related principally to carbon made from paper, which Edison claimed in his application. The case was not finally decided until the beginning of 1885. Mr. Broadnax was examined as a witness in this suit, and testified as follows: "After the decision of the Commissioner of Patents of the interference, awarding
1568 priority of invention to Sawyer and Man, I resumed the prosecution of the application, insisting upon our right to the claims that had been once rejected by the Examiner, among which was one for the U-shaped or loop carbon illuminant. My attention was then called for the first time by the Examiner to the British patent of Konn, in which is shown an arched-shaped carbon illuminant, and which as I thought, anticipated broadly the claim for the U-shaped, or arch-shaped carbon illuminant, and then in the discussion of the case with the Examiner, my attention was called to the patentability

of the fibrous carbon illuminant as such, on account of the properties such carbon possessed, which made it available for electric lighting above all other carbons." Being asked when this was, he said it followed soon after the decision of the Commissioner of Patents, upon the question of priority, or as soon as he could in the ordinary course get the case before the Primary Examiner again; his best recollection was that it occurred in February, 1885. 1569

This testimony of Mr. Broadnax, which is undoubtedly to be relied on, in connection with the letter just 1570
quoted shows, that the idea of claiming carbons made from fibrous and textile materials was an after-thought, and was no part of the purpose of the original application. The amendments relating to this new and broad claim were made afterwards, in February and March, 1885.

We are of opinion that the changes made in the application in this regard were not justifiable, and that the claim in question cannot be sustained.

There are other aspects of the case to which we 1571
might refer which operate strongly against the claim of the complainants. We are not at all satisfied that Sawyer and Man ever made and reduced to practical operation any such invention as is set forth and claimed in the patent in suit. Their principal experiments were made in 1878, and perhaps the beginning of 1879. The evidence as to what they accomplished in the construction of electric lamps is so contradictory and suspicious that we can with difficulty give credence to the conclusions sought to be drawn from it. We are not 1572
satisfied that they ever produced an electric lamp with a burner of carbon made from fibrous material, or any material, which was a success. During the year referred to, 1878, and the beginning of 1879, they applied for and obtained ten different patents (besides an English patent), on the subject of electric lamps; but not one of them contains a suggestion or a hint of any such invention as is claimed in the patent in suit, which was not applied for until 1880. They all relate to lamps with straight pencil burners, generally of car-

1573 bon, but without any preference given to one kind of carbon over another. The application for the patent in suit was not made until January, 1880, nearly or quite a year after all their experiments had ceased, and after the inventions of Edison had been published to the world. One cannot read the patents before applied for by Sawyer and Man, with all their detail of apparatus and process for constructing and managing the straight stem conductors, without distinction of carbons--apparatus and processes many of
1574 which would be needless in the lamp now claimed—without indulging some degree of astonishment at the pains and ingenuity gratuitously expended or wasted, if it was true that, all the time, they had in their possession a secret invention which would take the place of those complicated contrivances. The explanations made by the complainants for the delay in applying for the patent in suit fail to satisfy our minds that Sawyer and Man, or their assignees for them, have not sought to obtain a patent to which they were not legit-
1575 imately entitled.

But suppose it to be true, as the supposed inventors and some of the other witnesses testify, that they did in 1878, construct some lamps with burners of carbon made of fibrous material and of an arched shape, which continued to give light for days, or weeks, or months; still were they a successful invention? Would any one purchase or touch them now? Did they not lack an essential ingredient which was necessary to their adoption and use? Did they go any farther in prin-
1576 ciple, if they did in degree, than other lamps which had been constructed before? It seems to us that they were following a wrong principle—the principle of small resistance in an incandescing conductor, and a strong current of electricity; and that the great discovery in the art was that of adopting high resistance in the conductor with a small illuminating surface, and a corresponding diminution in the strength of the current. This was accomplished by Edison in his filamental thread-like conductors, rendered practicable by the perfection of the vacuum in the globe of lamp. He abandoned the

old method of making the globe in separate pieces, 1577
cemented together, and adopted a globe of one entire piece of glass, into which he introduced small platinum conductors fastened by fusion of the glass around them, thus being able to procure and maintain perhaps the most perfect vacuum known in the arts. In such a vacuum the slender filaments of carbon, attenuated to the last degree of fineness, may be maintained in a state of incandescence without deterioration, for an indefinite time, and with a small expenditure of electric force.
This was really the grand discovery in the art of electric 1578
lighting, without which it could not have become a practical art for the purpose of general use in houses and cities.

It is unimportant to trace the various steps by which this great discovery was arrived at. It is well indicated and shown in Edison's patent applied for in April, 1879, and issued May 4, 1880, Number 227,229; and is more fully described in that which he applied for November 4, 1879, and issued January 27, 1880,
Number 223,898. An extract from the latter will serve 1579
to explain the principles of this invention. Edison there says:

"Heretofore light by incandescence has been obtained from rods of carbon of one to four ohms resistance, placed in closed vessels, in which the atmospheric air has been replaced by gases that do not combine chemically with the carbon. The vessel holding the burner has been composed of glass, cemented to a metallic base. The connection between the leading-
wires and the carbon has been obtained by clamping 1580
the carbon to the metal. The leading-wires have always been large, so that their resistance shall be many times less than the burner, and, in general, the attempts of previous persons have been to reduce the resistance of the carbon rod. The disadvantages of following this practice are, that a lamp having but one to four ohms resistance cannot be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions; that, owing to the low resistance of the lamp, the leading-wires must

1581 be of large dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires pass in and are cemented; hence the carbon is consumed, because there must be almost a perfect vacuum to render the carbon stable, especially when such carbon is small in mass, and high in electrical resistance.

"The use of a gas in the receiver at the atmospheric pressure, although not attacking the carbon, serves to destroy it in time by 'air washing' or the attrition pro-
1582 duced by the rapid passage of the air over the slightly-coherent highly-heated surface of the carbon. *I have reversed this practice.* I have discovered that even a cotton thread properly carbonized and placed in a sealed glass bulb, exhausted to one-millionth of an atmosphere, offers from 100 to 500 ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures; that if the thread be coiled as a spiral and carbonized, or if any fibrous vegetable substance which will leave a carbon residue
1583 after heating in a closed chamber be so coiled, as much as 2,000 ohms resistance may be obtained without presenting a radiating-surface greater than three-sixteenths of an inch; that if such fibrous material be rubbed with a plastic composed of lamp-black and tar, its resistance may be made high or low, according to the amount of lamp-black placed upon it; that carbon filaments may be made by a combination of tar and lamp-black, the latter being previously ignited in a closed crucible for several hours and after-
1584 ward moistened and kneaded until it assumes the consistency of thick putty. Small pieces of this material may be rolled out in the form of wire as small as seven one-thousandths of an inch in diameter and over a foot in length, and the same may be coated with a non-conducting, non-carbonizing substance and wound on a bobbin, or as a spiral, and the tar carbonized in a closed chamber by subjecting it to high heat, the spiral after carbonization retaining its form.

"All these forms are fragile and cannot be clamped to the leading wires with sufficient force to insure good

contact and prevent heating. I have discovered that if 1585
platinum wires are used, and the plastic lamp-black and tar material be molded around it in the act of carbonization there is an intimate union by combination and by pressure between the carbon and platina, and nearly perfect contact is obtained without the necessity of clamps; hence the burner and the leading wires are connected to the carbon ready to be placed in the vacuum-bulb. When fibrous material is used the plastic lamp-black and tar are used to secure it to the platina before carbonizing. 1586

"By using the carbon wire of such high resistance I am enabled to use fine platinum wires for leading wires, as they will have a small resistance compared to the burner, and hence will not heat and crack the sealed vacuum bulb. Platina can only be used, as its expansion is nearly the same as that of glass.

* * * * * *

"I have carbonized and used cotton and linen thread, wood splints, papers coiled in various ways, also lamp-black, plumbago and carbon in various forms 1587
mixed with tar and kneaded so that the same may be rolled out into wires of various lengths and diameters. Each wire, however, is to be uniform in size throughout."

The first claim of this patent is for an electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires as set forth. The second claim is the combination of such filaments with the receiver made entirely of glass. 1588

Of course the form of the filament in the receiver or globe may be varied at pleasure; it may be in the shape of a coil, or of a horseshoe, or it may be wound on a bobbin. All these forms are old. The principal and great thing described is the attenuated filament, and its enclosure in a perfect vacuum. There may be a preference of materials from which the filament is made. Practice will evolve all these collateral advantages.

We think we are not mistaken in saying that but for

1589 this discovery electric lighting would never have become a fact. We have supposed it to be the discovery of Edison because he has a patent for it. This may not be the case; it may be the discovery of some other person. But whoever discovered it, it is undoubtedly the great discovery in the art of practical lighting by electricity. We have given a more detailed account of it in order to illustrate what we mean when we raise the question whether the claimed inventions of Sawyer and Man were ever successful. They may have made a lamp that would
1590 burn; but was it a success or was it a failure? Did it ever go into use? What was the object of all the experiments made by them and others? Was it not to make an electric lamp that could be successfully used by the public and have a commercial value? Did they succeed in making such a lamp, or in finding out the principle upon which it could be made?

We do not so read the evidence.

The bill must be dismissed.

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EUROPEAN FILAMENT LITIGATION.

Extracts from Decisions of the Courts of England and Germany sustaining Mr. Edison's Patents for the Filament of Carbon of High Resistance.

ENGLISH.

Patent No. 4576. dated November 10, 1879; Final Specification filed May 10, 1880.

CLAIMS:

1. An Electric Lamp for giving light by incandescence, consisting of a filament of carbon of high resistance; made as described and secured to metallic wires, as set forth.
2. The combination of a carbon filament within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted, for the purposes set forth.
3. A coiled carbon filament or strip arranged in such a manner that only a portion of the surface of such carbon conductor shall radiate light, as set forth.
4. The method herein described of securing the platina contact wires to the carbon filament, and carbonizing of the whole in a closed chamber substantially, as set forth.

GERMAN.

Patent No. 12,174, applied for November 26, 1879, and in force from the following day.

1. An Electric Lamp which gives light by incandesence, and, in the main, consists of a filament of carbon of high resistance, which is made as described, and secured to metallic wires.
2. A filament or strip of carbon fibres wound into spiral shape in such a way that only a part of the surface of the carbon radiates light.
3. The method herein described of securing the platina contact wires to the carbon filament, and carbonizing the whole in a closed chamber, as set forth.

MR. JUSTICE BUTT.

In the case of Edison vs. Woodhouse and Rawson, and Edison and Swan United E. L. Co. vs. Woodhouse and Rawson, for infringement and damages.

MAY 20TH, 1886.

Two questions were prominently at issue in this case: (1) infringement of the second claim, which was found to exist in the apparatus of the defendants; and (2) validity of the patent. It was urged that the claim was too comprehensive; that the specification was not clear; that a lamp made thereby would not be a good lamp; that at the time of the final specification Mr. Edison knew of a better method; and that the invention was not novel.

LORDS JUSTICES FRY AND BOWEN,

representing a majority of the Court of Appeal, sustaining the decision of Mr. Justice Butt.

JAN. 31st, 1887.

The first claim of the patent was not found to be infringed, narrowing the issue to the second claim. The utility of the invention was not called in question, but was affirmed by the Court.

The contention of the defendants was (1) lack of novelty; (2) that if novel the patent was vague, and consequently invalid, and (3) that what was new was not a good subject of a patent.

LORDS JUSTICES COTTON, LINDLEY AND BOWEN

of the Court of Appeal. Case of the Edison and Swan E. L. Co. vs. Holland. Appealed from decision of Mr. Justice Kay (delivered July 16th, 1888).

FEB. 18th, 1889.

The previous decision of Lords Justices Fry and Bowen was regarded here as binding in the matters of clearness of the specification, and reasonableness in the scope of the second claim. Hence the invention was considered good subject-matter for a patent.

Defendants' effort was to prove (1) anticipation by Swan, upon which issue the decision in great measure hinged; (2) lack of utility by taking the position that tar-putty filaments were worthless; (3) vagueness in describing the nature of the invention and the methods of manufacture.

The Court dwelt forcibly upon the construction of the term "carbon filament."

GERMAN IMPERIAL PATENT OFFICE.

Motion by Swan United E. L. Co., Limited, of London, to declare patent entirely or partially invalid.

JAN. 24th–FEB. 15th, 1884.

Plaintiff makes the principal motion to declare all three patent claims null and void, or as a substitute to restrict them so that claims 1 and 3 combined will read as follows:

"In an electric lamp which gives light by incandescence, the employment of carbon conductors consisting of a mixture of lampblack and tar, and fastened with the same material during carbonization to the platina contact wires."

Plaintiff, in the contingent motion, asks for the following wording of claim 2:

"The employment of a filament or strip of carbon fibres which is made as specified in claim 1, and coated with non-conducting non-carbonizable material, and wound in spiral shape, so that only part of the surface radiates light."—EXTRACT FROM THE DECISION.

ROYAL GENERAL COURT OF JUSTICE OF BERLIN.

Civil suit of Thomas A. Edison vs. Naglo Bros. (representing the Swan Company) for infringement and damages.

MARCH 9TH, 1885.

Defendants use and introduce into the trade electric incandescent lamps, the essential features of which consist of an incandescent carbon wire enclosed in a hermetically sealed glass vessel, wholly or partially exhausted, which carbon wire is made from a cotton thread parchmentized before carbonization by the action of sulphuric acid, and connected with thin platina wires fused into the glass.—EXTRACT FROM THE JUDGMENT.

Elements of the Invention.

Mr. Justice Butt: I find a vessel made entirely of glass containing a carbon filament attached to conducting wires, which wires are sealed through the glass. I find that this vessel has to be exhausted of its air to a very great degree, the patentee claiming that one millionth of an atmosphere may be left.

Lords Justices Fry and Bowen:

1. The coiling or arranging a light-giving body of carbon wire or sheets, so as to make the resistance high in proportion to the light-giving surface.
2. The placing of the light-giving body in a nearly perfect vacuum.
3. The conducting of the current into the vacuum bulb through platinum wires sealed into the glass.
4. The mode of manufacturing carbon conductors.
5. The mode of securing perfect contact between the metallic wires and the carbon.

German Imperial Patent Office: The contested Patent No. 12,174, protects a certain kind of electrical incandescent lamps, the chief peculiarity of which consists in the employment of a carbon fibre of high resistance for the purpose of giving light.

Royal General Court of Justice of Berlin: The idea of invention protected therein consists in the construction of an incandescing body of filamentary form of carbon manufactured by carbonizing cotton fibre to which can be given the coiled shape by bending; consequently in the method of creating an incandescing body, by working the otherwise brittle carbon into loops, spirals, etc., which body in its tenacity approaches the metals, but at the same time can resist the action of much higher temperatures, and possesses such an electric resistance as to allow of the division of the electric current.

Features of the Conductor.

Lords Justices Fry and Bowen:

1. Cotton thread properly carbonized, which is stated to offer from 100 to 500 ohms resistance to the passage of the current.
2. Any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber.
4. Such fibrous material as before-mentioned rubbed with a plastic compound of blacklead and tar.
5. A combination of tar and lampblack, or plumbago or carbon in other forms, the tar being subsequently carbonized by being subjected to high heat in a closed chamber.
6. The last described, coated for the purpose of support with a non-conducting, non-carbonizing substance.

It was perfectly well known that light was to be produced * * * by resistance in a conductor * * * depending on four conditions or factors:

(1) Temperature * * *

(2) The specific resistance of the matter of which the conductor is formed.

(3) Length * * *

(4) Sectional area.

Lords Justices Cotton, Lindley and Bowen: The meaning of the expression "carbon filament" appears to me to be the crucial point for determination when dealing with the question whether the nature of the invention is particularly described. This point moreover is, in my judgment, by far the most difficult in the whole case. Everything, I think, turns upon it; * * * I have come to the conclusion that what is meant by the expression "carbon filament" can be gathered from the instances given in the specification, and that what is meant is any thread which can be and is bent into the required form, and can be and is carbonized when so bent. The thread, as shown by the examples, may be a fibre or a group of twisted fibres; or, as is to be gathered from the tar lampblack instance, it may be an artificial substance pressed or rolled into thread or wire-like forms. * * * The sense can be gathered from the typical examples given in the specification, and referred to in the judgment of Lord Justice Fry. * * * The size of the filament is not stated, but it is quite clear from the objects to be attained that it must be long and thin, and nothing more definite is necessary to be stated.—LINDLEY.

Royal General Court of Justice of Berlin: The practical success of Swan's operation consists, according to the opinion of the Patent Office of April 5, 1884, in the fact that the texture of vegetable fibre is destroyed in the cotton thread. But this circumstance is not sufficient to establish a material difference between Swan's and Edison's incandescing body. How little weight the latter attributes to the vegetable fibrous texture of the carbon filament, may be estimated when he admits a filament formed of tar and lampblack (where a fibrous texture is out of the question) as a choice side by side with the cotton thread. It is only necessary that as an incandescing body a carbon of the peculiar filamentary form is used.

The substance of the present invention of Edison is based on the fact that in the first place a thread-like incandescing body of carbon substance is made to which by bending could be given a coiled shape. * * * If, afterwards, the discovery is made that these carbon filaments can be bent even before carbonizing, it cannot be assumed, because Edison unnecessarily prescribes that the bending should be done before carbonization, that a lamp provided with such a flexible carbon conductor could be made without the use of Edison's idea.

Analysis of 1st, 3d and 4th Claims.

Mr. Justice Butt: I now think that there is no infringement of Claim No. 1. * * * But in the view I take of Claim No. 2 this question becomes unimportant. [illegible]

Lords Justices Fry and Bowen: The first claim we understand to be for the entire lamp—that is, for all the elements of the invention brought together in one combination.

German Imperial Patent Office: Regarding the method of production of the carbon fibre, reference is made in claim No. 1 to the patent specification * * * From this, two conclusions are drawn [illegible] on the one hand, that by the

Royal General Court of Justice of Berlin: The Court has gained the conviction that by the manufacture of the Swan lamps, claim No. 1 of the plaintiffs' patent is being infringed, inasmuch as the same covers as an [illegible] part of the

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this entire combination, and, consequently, that there is no infringement of the first claim.

The entire combination, the subject of the first claim, is subdivided into three subordinate parts or combinations, the subjects of the second, third and fourth claims.

The third claim is for that peculiar arrangement for coiling or similar process by which a portion only of the carbon conductor radiates light; the fourth claim is for the attachment of platina contact wires to the carbon filament and the carbonizing of the whole in a closed chamber, so that the third and fourth claims are those very portions of the entire combination which are not in the second claim.

term "carbon fiber," used in the patent, not simply any carbon of vegetable origin is meant, but only the carbon filament made and shaped in this peculiar way; on the other hand, that * * * whenever in the specification platina wires are spoken of, they are only intended to connect the carbon filament with the conducting wires on the outside of the glass globe.

patented invention as a whole, the production an incandescing body of filamentary form for electric lamps by carbonization of cotton thread or other fibrous material (linen thread, wool splints, paper), or a dough made from tar and lampblack (eventually graphite carbon). *The two opinions of the Imperial Patent Office of April 5 and December 30, 1884, declare this incandescing body to be an essential element of plaintiff's patent.*

Scope of Second Claim.

Now, the question of the infringement of Claim No. 2 depends on the meaning to be attached to the words in it—"a carbon filament."

If those words mean a carbon filament made as described in the patent, I should hold that there was no proof of its infringement; but I do not so interpret those words. I hold them to mean any carbon filament, however made, which possesses certain qualities or properties mentioned in the specification or necessarily resulting from the description there given.

To answer that description the carbon filament must, I think, possess flexibility and resilience; it must be of small cross-section, offering a high degree of resistance to the passage of the electric current, and it must present but a small surface from which radiation of light can take place. In the second place, I hold that, attributing the meaning I have to Claim No. 2, there has been a clear infringement by the defendants of that claim.

In our opinion this claim ought to be construed with all the generality which its words seem to convey, so that it may be paraphrased as a claim to every combination of any carbon filament with any receiver made entirely of glass through which any leading wires pass and from which the air is exhausted.

This second claim embraces a combination of

(1) a carbon conductor;

(2) in the form of a filament;

(3) a receiver wholly of glass;

(4) a vacuum;

(5) the entrance of the leading wires through a glass receiver.

It is satisfactory to find that the wide construction of the second claim was fully present to the minds of the counsel for the defendants when conducting the case in the court below.

The problem before Mr. Edison was to find some conductor in which he could obtain high resistance to the current with great durability. * * * Mr. Edison satisfied the conditions of this problem by using carbon, a substance of low conductivity, in a form in which the length of the conductor was great in proportion to its sectional area, and by placing this conductor in a chamber not occupied by an inert gas like nitrogen, but by a vacuum as complete as is obtainable.

The importance of this combination can hardly be doubted, for, if not alone, yet in combination with other improvements, it has had this result that, whereas, before November, 1879, two or three experimental lamps were all that had been produced, after that date such lamps have been produced by tens of thousands and constitute a most important element in our methods of lighting.

This Court has had to consider this patent before (page 687, marked portion). The construction of the specification which I consider binding, involves three points, namely, first, that the specification is not too vague and unintelligible to be construed by the Court; secondly, that what is meant by "carbon filament" is reasonably plain from the specification itself; and thirdly, that the second claim, as construed by the Court, is not so wide as to invalidate the patent. * * *

I ought to notice the very formidable objection taken by Mr. Justice Kay to the validity of the patent, on the ground that the second claim is for a monopoly of incandescent lamps containing a filament of carbon for a burner, and that such claim is far too wide, considering how much Edison had invented. Whether the view here taken of the patent is correct or not turns, in my opinion, on what Mr. Edison did when he introduced "carbon filaments." That was, I think, a new departure of the highest importance in electric lighting, and if this be so, the claim is not too wide.—LINDLEY.

The patent appears to me to claim in distinct and unmistakable language every combination of any carbonized filament with any receiver of glass, through which leading wires pass, and from which the air is exhausted. * * * Construing claim 2 as embracing all combinations such as I have mentioned, is it too vague? I see no reason to doubt that in the year 1879 the term "filament," though new at that date as regards electric lighting, would, nevertheless, convey to the minds of ordinary persons of the class to whom this specification was addressed the idea of a slender thread, or thread-like substance, and it seems to me that the specification indicates that the thread or filament was first to be formed, and then to be subsequently carbonized. * * * The term "filament" is nowhere defined. It is a descriptive term, not a definition. But it appears to me to indicate the nature of this particular factor in the combination in a way that describes and ascertains the nature of the invention, so as to render it plainly intelligible to a skilled person of the class to whom the specification is addressed. * * * The merits of a filament, as distinguished from a rod, are manifest. The filament, or thread has an extremely small sectional area; it is flexible before carbonization, and resilient afterwards. It is true that these merits are not explained, but I know of no law which renders it incumbent on the patentee in such a case to explain them. It appears to me, moreover, to be proved not only that every successful lamp since 1879, which is available for multiple arc lighting, has employed a filament, but also that there is no proof yet that any fila- [illegible] the invention that it covers so large a field.—BOWEN.

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Novelty, Not Vague, Legitimate.

It is said, a carbon filament when taken to mean that which I have held it to mean, is a description too vague and indefinite, or to use the Solicitor-General's own words, too large. That is an argument to which I cannot accede, for I see no reason why a carbon filament having the properties mentioned in Mr. Edison's patent, and which the patentee tells the public how to make, may not properly be the subject of a patent, although it is capable of being made by methods and of materials other than those set forth in the specification. This observation certainly does not lose any of its force when the filament in question is not the thing patented, but only one of the several parts of a combination patented.

It is said that the specification is not such as would enable a competent workman to make the lamp. * * * I hold, therefore, that the evidence does establish that the specification in question is one which would enable a competent workman to make the lamp.

On the whole, I have come to the conclusion, first, that there is no sufficient reason for saying that this patent is invalid on any of the grounds suggested on the part of the defendants, amongst others, of course, that there is no ground for the assertion that it had been anticipated.

It may well be said that no patent could be sustained for the use of a filament of carbon alone; but when that filament is part of a combination which is useful, and replaces a rod in an earlier apparatus which was useless, we can see no reason why the new useful combination may not be the good subject of a patent.

It is urged that the combinations claimed in Claims 2 and 3 according to the true reading of them, are not novel; that if novel the second claim is expressed with a vagueness which is fatal to its validity, and that what was new in that claim is not a good subject of a patent. * * *

The specification is itself argued bad, as being too indefinite and vague. * * * In a patent of this description definition is required only to such an extent as would enable a practical workman to construct the required apparatus. * * * There is distinct evidence that such a workman could make the required apparatus from the specification.

An objection * * * was that the specification did not sufficiently show how the invention is to be carried into effect. * * * In my opinion it is not necessary that "a person skilled in the particular kind of work" should be able to do the work without any trial or experiment, which when it is new or especially delicate may frequently be necessary, however clear the description may be. * * * I think that this objection fails.—COTTON.

The validity of the patent in question on this appeal is disputed on two broad grounds, viz.: 1st, because the patentee has not particularly described and ascertained the nature of his particular invention. Secondly, because he has not particularly described and ascertained in what manner the same is to be performed. * * *

In my opinion the patentee has "particularly described and ascertained the nature of the invention." * * * I cannot agree in thinking that the manner in which the invention is to be performed is not stated with sufficient clearness to support the patent. * * * I cannot myself come to the conclusion that the patentee has kept back any secret that he possessed by virtue of which he could in 1879, make carbon filaments better than other persons possessed of reasonable skill and who followed the directions contained in the specification with a *bona fide* desire to succeed.—LINDLEY.

I think this patent constituted a new departure in electricity, that the specification sufficiently describes and ascertains the nature of the invention, and that no reasonably competent operator alive to the delicacy and care obviously requisite in forming and carbonizing so slight a thing as a filament ought, without any exercise of invention, but with reasonable watchfulness only and fair good will, to have been embarrassed in making and carbonizing Mr. Edison's filaments.—BOWEN.

The circumstance that certain elements in the Edison lamp not patented themselves, as, for instance, the use of vegetable carbon as the incandescing body, the spiral form of the same, etc., were known before the application for the patent, cannot bring into question the total construction of the lamp as protected by claim No. 1.

As regards claim 2, the plaintiff makes an erroneous interpretation of the law when he assumes a possibly insufficient description to be made a legal reason for annulling. Moreover, the maintainance of claim No. 2 is justified by the fact * * * that the carbon fibre or rather the carbon filament, in spite of all the publications cited by the plaintiff, must be regarded as novel.

The assertions of defendants that this alleged invention of Edison is not novel, and that the lamps manufactured in accordance with Patent No. 12,174 are not practically useful, are irrelevant in the present suit, but belong to the pending action seeking an annulment of plaintiff's patent.

The lamps put on the market by defendants undoubtedly contain an incandescing body made by carbonizing a cotton thread, to which, by bending, the desired shape has been given. Therein an infringement of plaintiff's patent must be found. The method employed by Swan to parchmentize the cotton thread before carbonization may contain an improvement on Edison's process, but it does not justify the use of the latter without Edison's permission.

The infringement of a patent by manufacturing imitations does not necessarily call for a complete copy of the patented invention, but it suffices if the latter is reproduced in some essential parts, or if the imitation coincides only in certain essential protected points with the object of the patented invention.

If, therefore, defendants emphasize their statement that plaintiff separates his three claims while they would not have been patentable each for itself, in order to prove that the use of one of the devices described in plaintiff's claims does not constitute an infringement of Edison's patent, this objection is set aside by the consideration that, if different improvements are made the object of the patent, the several separate claims contain the different inventions all relating to the patented construction as a whole, but embodying separate ideas of invention, and enjoy therefore independent patent protection, each for itself. Moreover, the point at issue is the "invention" rather than the claims, as the law does not recognize "Patent Claims" and only "inventions" are patented, all the essential elements of which are protected by the patent.

Utility.

It is said that a lamp made according to the specification would not be a good lamp. * * * There is evidence from the plaintiff's witnesses to the contrary, and, moreover, the Solicitor-General expressly stated that he did not dispute the utility of Mr. Edison's specification.

There was distinct evidence of the utility of the combination contained in the second claim, not so far as was shown us, met by any opposing evidence. Indeed, the utility of the patent, and consequently of everything actually claimed by it, is not in dispute.

Inventions for the improvement of carbon filaments followed quickly on the patent of November, 1879, which greatly assisted in the manufacture and the durability of the burner. * * * That in my opinion was a useful combination; and a patent is not to be defeated simply because subsequent inventions improved the patented article, or because in consequence of such subsequent improvements no article was in fact made in accordance with the specification. But, in my opinion, it is established by the evidence that in fact incandescent lamps were made by Edison in accordance with the specification of November 10, 1879, and even sent by him to Dr. Hopkinson, and publicly run by him in March, 1880. I do not see any fact now brought before us which ought to induce the Court to depart, or would justify the Court in departing, from the previous decision of the Court on the question of the invention being useful, and being the good subject matter for a patent—COTTON.

If the invention was then useful, the fact that subsequent improvements have replaced the patented invention and rendered it obsolete and commercially of no value, does not invalidate the patent. * * * Lamps having the carbon filaments in combination with the other essentials mentioned in the second claim are in constant use, and their utility is proved by the fact that this particular combination is used by the defendants and by everyone, in fact, who makes incandescent electric lamps. The utility of the patented invention, meaning thereby the above combination, is incontestable.—LINDLEY.

Improvements of real value followed with great rapidity on the patent and were naturally utilized. Their rapid succession does not destroy the legal validity as regards usefulness of the original combination to which such improvements were felicitously applied.—BOWEN.

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SWAN: The only alleged anticipation which I need consider is that

In none of the public prints referred to * * * is a description

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provements have replaced the patented invention and rendered it obsolete and commercially of no value, does not invalidate the patent. * * * Lamps having the carbon filaments in combination with the other essentials mentioned in the second claim are in constant use, and their utility is proved by the fact that this particular combination is used by the defendants and by everyone, in fact, who makes incandescent electric lamps. The utility of the patented invention, meaning thereby the above combination, is incontestable.—LINDLEY.

Improvements of real value followed with great rapidity on the patent and were naturally utilized. Their rapid succession does not destroy the legal validity as regards usefulness of the original combination to which such improvements were felicitously applied.—BOWEN.

Alleged Anticipations.

It is perfectly true that a number of specifications and other publications anterior to Mr. Edison's patent have been adduced describing either the separate parts of Mr. Edison's combination or something like them. Without losing sight of the others, I refer especially to those of Mr. Lane-Fox, Mr. Pulvermacher, M. Sido, and Mr. Swan.

FOX—It seems to me that the Solicitor-General was perfectly warranted when he said it was abundantly clear from the different specifications of Mr. Lane-Fox that he had realized and knew of the elements that were necessary to make a good incandescent lamp * * * but then, as I understand the matter, like Mr. Pulvermacher, when he comes practically and finally to deal with the matter he disclaims it, and it drops out of his patents, evidently because he did not know how to make an efficient carbon conductor. The carbon conductor he had described he must have thought, and he says, in fact, was less desirable than the metallic, under all circumstances, and he did not know how to make one that would be better.

PULVERMACHER—It is perfectly clear to my mind that Mr. Pulvermacher was wholly unaware that a coiled thread of carbon could be applied to the purpose of incandescent lamps, because he certainly would not have discarded it when he came to make his incandescent lamp, which is provided for in the very same patent.

SWAN—But not one of those specifications, unless it be Swan's, contains the combination described in Mr. Edison's patent. * * * At all events, if we except Swan's, none of the other publications contained a combination of all the elements of Mr. Edison's. * * * The question therefore is—the main question to my mind—are Mr. Swan's carbon rod or pencil and Mr. Edison's carbon filament practically the same thing? Now, I think they are not. * * * To my mind it does seem to me that a carbon pencil or rod is a very different thing from a carbon filament. * * * It seems to me to carry one a long way on the road to that conclusion to say that a rod or pencil is a rod or pencil, and a thread is a thread.

Mr. Edison's conductor possesses a smallness of cross-section, combined with other properties, which Mr. Swan's does not; Mr. Edison's possesses a degree of flexibility, which, to my mind, is not even approached by Mr. Swan's. * * * I think there is no evidence to show that before Mr. Edison's specification (Swan) knew how to make a carbon conductor or anything like so small a cross-section which would answer to the other requirements stated.

Dr. Odling, one of the defendant's witnesses, says * * * As applied to a conductor exclusively of carbon, I cannot point out any anticipation of Edison's statement contained in the passage from line 23 to line 43, page 3 of the specification.

A rose does not smell any sweeter for being called a rose, and the fact that Mr. Swan did subsequently call that rod a filament does not at all convince me that it was properly so called. * * * All manner and kinds of carbon conductors * * * have since among electricians acquired the name of filament, but I suspect it would be found they have acquired the name of filament since flexibility was introduced and rigidity was tabooed.

KING, 1845—Proposed the use of two kinds of conductors, metallic and carbon. The metallic * * * incandescent in the air. The carbon * * * in a space from which the air and moisture were excluded * * * a barometer tube * * * enlarged * * * carbon of the kind found in the interior of coal gas retorts, formed into a small pencil or thin plate, but of a width * * * greatly exceeding that of the conducting wires.

We find a carbon and a vacuum * * * the carbon not required to be a filament * * * in a receiver made, not entirely of glass, but partly of glass and partly of the top of the mercury column, consequently that the leading wires were to pass, one through the glass and one through the mercury.

ROBERTS, 1852—Mr. Roberts did not use carbon as his sole material; that he was content with the exclusion of gases chemically destructive, and was not alive to the importance of the mechanically destructive action of gases; that his receiver was not made entirely of glass, and that the leading wires did not pass through glass, but through the metallic cap of the receiver.

FOX—First lamp, October 9, 1878, No. 3988. Atmosphere of nitrogen gas * * * only material he mentions is an alloy of platinum and iridium * * * not the carbon in the filament, not the glass receiver and not the vacuum of Mr. Edison.

FOX—Second lamp, October 12, 1878, No. 4043. In the first form of conductor we have a metal and not a carbon; * * * in the second * * * asbestos or some other non-conducting refractory material saturated or impregnated with a conducting body, such as carbon or iridium; * * * we miss, too, the vacuum.

FOX—Third lamp, November 14, 1878, No. 4626. The conductor * * * was nothing other than a repetition of the second form * * * of October 12.

FOX—Fourth lamp, March 20, 1879, No. 1122. A mixture of two highly refractory materials, one a conductor, * * * the other badly conducting material. * * * It is evident that we have here neither the carbon conductor of the filamentous form, nor the vacuum of Mr. Edison.

VAN CHOATE—October 31, 1878, No. 4388. Vaguely described as composed or formed of asbestos, mica, platinum or carbon, or any combination of them, and such other materials as may be required to give the proper affinity and homogeniety to the material. It is evident that this is no adequate description to enable any one without further experiment to ascertain of what the conductor is to be made, or of what form it is to be * * * It is obvious that the purposes for which Edison uses a coil, namely the diminution of the radiating surface and the raising of the specific heat of the whole, were not only absent from the mind of Van Choate, but would not result from large spirals which are manifestly within his provisional specification.

PULVERMACHER, Nov. 23, 1878. No. 4774. A spiral or screw-shaped rod was used, but this was for the purpose of illumination, not by incandescence but by the voltaic arc, and consequently it had no real relation to the coil of Mr. Edison's lamp.

There is no evidence that a single lamp made under any one of the specifications or provisional specifications we have referred to ever gave a ray of light.

SWAN, Exhibited Dec. 19, 1878. A lamp constructed entirely of glass, containing in vacuo platina leading wires hermetically sealed into a glass, between which wires was suspended a rod or pencil of carbon, slender, but not so slender as to be described as a filament. This produced incandescent light for a time. * * * On the 3d of February, 1879, Mr. Swan * * * exhibited a second lamp of the same construction which gave out a very considerable incandescent light for some 20 minutes. * * * On the 2d March, 1879, Mr. Swan again described his lamp * * * but it does not appear that he exhibited it, and from that time it has, so far as this case is concerned, disappeared from history, and this disappearance is, we think, cogent evidence that Swan's lamp as it was exhibited, was not a practical success; that Swan could not do what Edison did, and that the difference between a carbon rod and a carbon filament was the difference between failure and success.

SWAN: The only alleged anticipation which I need consider is that of Swan's lamp * * * exhibited in December, 1878, and February and March, 1879, by Mr. Swan. In the previous case, on the evidence then before us, I thought this lamp would, on the construction put by the majority of the Court on the specification, be an anticipation. * * * But we have now evidence which was not before the Court in the former action, of what was being done by Mr. Swan and Mr. Stern after the experimental trial of this lamp. * * * We see that that lamp was treated by them as a failure, and that their attempt to correct its defects led to lamps which differed more widely from it than the lamp described in Edison's patent. This evidence assists the conclusion at which the Court arrived in the former action, that Swan's lamp of 1879 was not a success, and I think enables me to come to the conclusion that this lamp was an experiment which failed, and was abandoned, and that the difference introduced by Edison was one which changed failure into success. * * * There was direct evidence by Swan that he did not make any thread carbon lamp before 1880, * * * and I am satisfied that the witnesses were mistaken in fixing the date as 1879.—COTTON.

The correspondence between Swan and Stearn shows, I think, to demonstration that till the middle of the year 1880 Mr. Swan did not consider himself to be upon the right track. The dates put forward by the witnesses Proctor and Heaviside seem to me to be unreliable and inaccurate, and I think there is reason for believing that it was Mr. Edison's patent which led back the world of electricians to the true path. Certainly, from the date of its exhibition, that Swan lamp disappeared from history until it was exhumed for the purposes of the trial in the Woodhouse case.—BOWEN.

In none of the public prints referred to * * * is a description of an incandescent lamp to be found which possesses the characteristic peculiarities of the Edison lamp as they are above set forth, especially the use of suitably made carbon thread for giving light by incandescence.

Of the different applications referred to, first of all, those treating of arc lamps should be left unconsidered.

BINKS, (English) No. 119 of 1853. Against the novelty of claim No. 3 only this has been cited, which, as it relates to arc lamps, must be left out.

HARRISON, (English) No. 3,470, of 1878. (Arc lamp.)

SAWYER-MAN. ("Scientific American," Vol. 40, p. 145.)

ROBERTS, (English) No. 14,198 of 1852.

All employed vegetable carbon as the incandescing body, not in the peculiarly made filamental form which is the chief characteristic of the Edison lamp, but in rods, pencils, pieces.

SWAN. The lamp submitted at the hearing likewise shows a comparatively thin carbon rod.

None of these lamp systems can, therefore, be regarded as identical with the Edison patent.

KING, (English) No. 10,919 of 1845, employs as an incandescing body a platina strip.

LANE-FOX, (English) No. 4,626, of 1878, a platina or iridium spiral, and also a mixture of conducting and non-conducting material. (No. 1,122 of 1879.)

These patents, therefore, bear no relation to the German Patent, which employs a carbon filament.

CHOATE, (English) No. 4,388, of 1878. If Choate has already prescribed the spiral form for the incandescing body, it is irrelevant, inasmuch as by the method of Choate the incandescing body is made from metallic or semi-metallic substances and not in the manner described by Edison. * * * The process of the coating of a metallic conductor as described by Choate is essentially different from claim No. 3, for with Choate the coating is not intended to establish a connection between the incandescing body and the outside conducting wires, but rather to increase the resistance of the metallic conductor, which serves as an electrode.

Failure vs. Success.

There is one fact which is either admitted or beyond contest in the case, and that is, that before the date of the specification in question, no good and efficient incandescent electric lamp was made or known.

The rapidity with which the patents succeeded one another in 1878 and 1879 shows how keen was the race for the production of a good incandescent electric light, and the fact that no one of the inventors in question is shown ever to have succeeded seems to be strong evidence that every one of the ingenious apparatus which they devised resulted in failure.

There was no case in which there was brought together all the five elements * * * combined in Mr. Edison's second claim. * * * Two, and, so far as we have learned, only two specimens of the earlier forms of the instrument have been constructed, and in both of these a rod and not a filament of carbon had been adopted. Mr. Edison used the filament instead of the rod for a definite purpose, and by the diminution of the sectional area made a physical law subserve the end he had in view. The smallness of size, therefore, was no casual matter, but was intended to bring about, and did bring about, a result which a rod could never produce, and so converted failure into success. The point upon which Mr. Edison's instrument departed from Mr. Swan's was crucial, and the departure, though slight, had all the merits of a new invention, and produced a new apparatus.

If Swan's lamp * * * had been a success instead of a failure, it would, in my opinion, have been an anticipation of the plaintiff's patent. The evidence, however, shows that it was a failure, and that Swan had not got the key to success. His own efforts to improve this lamp show that he was not thinking of filamentous incandescent carbons, but of other matters. * * * I agree with Lord Justice Fry in thinking that "the point at which Mr. Edison's instrument departed from Mr. Swan's was crucial, and the departure, though slight, had all the elements of a new invention, and produced a new result." * * *

One mode of trying this question is to ask whether any one would make such a thing as Swan's lamp if he took Edison's specification as his guide. I am convinced he would not; he would avoid and not reproduce Swan's carbon pencil, and would adopt Edison's type of carbon in the carbon filament. The two may be made to shade off into each other until it becomes impossible to draw the line sharply between them; but this does not prevent a man from perceiving the difference between the two types or from adopting the one which succeeds in preference to the one which fails.—LINDLEY.

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46

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Frederick, Maryland
1987

Association for Information and Image Management

MS303-1980

Centimeter

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 mm

1 2 3 4 5

Inches

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0 4.5 5.0